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(54) Title: REGULATION OF HUMAN HISTONE DEACETYLASE

(57) Abstract: Reagents which regulate human histone deacetylase and reagents which bind to human histone deacetylase gene products can play a role in preventing, ameliorating, or correcting dysfunctions or diseases including, but not limited to, cancer.

REGULATION OF HUMAN HISTONE DEACETYLASE

TECHNICAL FIELD OF THE INVENTION

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The invention relates to the area of enzyme regulation. More particularly, the invention relates to the regulation of human histone deacetylase and its regulation.

BACKGROUND OF THE INVENTION

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Histone deacetylase and histone acetyltransferase together control the net level of acetylation of histones. U.S. Patent No. 6,110,697; Cress & Seto, *J. Cell. Physiol.* 184, 1- 16, 2000; Hu *et al.*, *J. Biol. Chem.* 275, 15254-64, 2000; Davie & Spencer, *J. Cell. Biochem. Suppl.* 32-33, 141-48, 1999. Inhibition of the action of histone

15 deacetylase results in the accumulation of hyperacetylated histones, which in turn is implicated in a variety of cellular responses, including altered gene expression, cell differentiation and cell-cycle arrest. Thus, agents which regulate the activity of histone deacetylase can be useful as therapeutic agents for a wide variety of disorders.

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SUMMARY OF THE INVENTION

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It is an object of the invention to provide reagents and methods of regulating a human histone deacetylase. This and other objects of the invention are provided by one or more of the embodiments described below.

One embodiment of the invention is a histone deacetylase polypeptide comprising an amino acid sequence selected from the group consisting of:

30

amino acid sequences which are at least about 52% identical to the amino acid sequence shown in SEQ ID NO: 2; and

the amino acid sequence shown in SEQ ID NO: 2.

Yet another embodiment of the invention is a method of screening for agents which
5 decrease extracellular matrix degradation. A test compound is contacted with a
histone deacetylase polypeptide comprising an amino acid sequence selected from
the group consisting of:

amino acid sequences which are at least about 52% identical to the amino acid
10 sequence shown in SEQ ID NO: 2; and

the amino acid sequence shown in SEQ ID NO: 2.

Binding between the test compound and the histone deacetylase polypeptide is
15 detected. A test compound which binds to the histone deacetylase polypeptide is
thereby identified as a potential agent for decreasing extracellular matrix degradation.
The agent can work by decreasing the activity of the histone deacetylase.

Another embodiment of the invention is a method of screening for agents which
20 decrease extracellular matrix degradation. A test compound is contacted with a poly-
nucleotide encoding a histone deacetylase polypeptide, wherein the polynucleotide
comprises a nucleotide sequence selected from the group consisting of:

nucleotide sequences which are at least about 50% identical to the nucleotide
25 sequence shown in SEQ ID NO: 1; and

the nucleotide sequence shown in SEQ ID NO: 1.

Binding of the test compound to the polynucleotide is detected. A test compound
30 which binds to the polynucleotide is identified as a potential agent for decreasing

extracellular matrix degradation. The agent can work by decreasing the amount of the histone deacetylase through interacting with the histone deacetylase mRNA.

5 Another embodiment of the invention is a method of screening for agents which regulate extracellular matrix degradation. A test compound is contacted with a histone deacetylase polypeptide comprising an amino acid sequence selected from the group consisting of:

10 amino acid sequences which are at least about 52% identical to the amino acid sequence shown in SEQ ID NO: 2; and

the amino acid sequence shown in SEQ ID NO: 2.

15 A histone deacetylase activity of the polypeptide is detected. A test compound which increases histone deacetylase activity of the polypeptide relative to histone deacetylase activity in the absence of the test compound is thereby identified as a potential agent for increasing extracellular matrix degradation. A test compound which decreases histone deacetylase activity of the polypeptide relative to histone deacetylase activity in the absence of the test compound is thereby identified as a
20 potential agent for decreasing extracellular matrix degradation.

Even another embodiment of the invention is a method of screening for agents which decrease extracellular matrix degradation. A test compound is contacted with a histone deacetylase product of a polynucleotide which comprises a nucleotide
25 sequence selected from the group consisting of:

nucleotide sequences which are at least about 50% identical to the nucleotide sequence shown in SEQ ID NO: 1; and

30 the nucleotide sequence shown in SEQ ID NO: 1.

Binding of the test compound to the histone deacetylase product is detected. A test compound which binds to the histone deacetylase product is thereby identified as a potential agent for decreasing extracellular matrix degradation.

5 Still another embodiment of the invention is a method of reducing extracellular matrix degradation. A cell is contacted with a reagent which specifically binds to a polynucleotide encoding a histone deacetylase polypeptide or the product encoded by the polynucleotide, wherein the polynucleotide comprises a nucleotide sequence selected from the group consisting of:

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nucleotide sequences which are at least about 50% identical to the nucleotide sequence shown in SEQ ID NO: 1; and

the nucleotide sequence shown in SEQ ID NO: 1.

15

Histone deacetylase activity in the cell is thereby decreased.

The invention thus provides a human histone deacetylase which can be used to identify test compounds which may act, for example, as activators or inhibitors at the
20 enzyme's active site. Human histone deacetylase and fragments thereof also are useful in raising specific antibodies which can block the enzyme and effectively reduce its activity.

BRIEF DESCRIPTION OF THE DRAWINGS

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Fig. 1 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 1).

Fig. 2 shows the amino acid sequence deduced from the DNA-sequence of Fig.1
30 (SEQ ID NO: 2).

- Fig. 3 shows the amino acid sequence of the protein identified by SwissProt
Accession No. P56523 (SEQ ID NO: 3).
- Fig. 4 shows the amino acid sequence of the protein identified by trembl
Accession No. AF132609 (SEQ ID NO: 4).
- Fig. 5 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 5).
- Fig. 6 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 6).
- Fig. 7 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 7).
- Fig. 8 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 8).
- Fig. 9 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 9).
- Fig. 10 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 10).
- Fig. 11 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 11).
- Fig. 12 shows the DNA-sequence encoding a histone deacetylase Polypeptide
(SEQ ID NO: 12).

- Fig. 13 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 13).
- 5 Fig. 14 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 14).
- Fig. 15 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 15).
- 10 Fig. 16 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 16).
- Fig. 17 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 17).
- 15 Fig. 18 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 18).
- Fig. 19 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 19).
- 20 Fig. 20 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 20).
- Fig. 21 shows the DNA-sequence encoding a histone deacetylase Polypeptide (SEQ ID NO: 21).
- 25 Fig. 22 shows the BLASTP alignment of human histone deacetylase (SEQ ID NO: 2) with the protein identified with SwissProt Accession No. P56523 (SEQ ID NO: 3).
- 30

Fig. 23 shows the BLASTP alignment of 355_protein (SEQ ID NO: 2) against trembl|AF132609|AF132609_1 (SEQ ID NO: 22).

Fig. 24 shows the BLASTP - alignment of 355_protein against pdb|1C3P|1C3P-A.

5

Fig. 25 shows the HMMPFAM - alignment of 355_protein against pfam|hmm|Hist_deacetyl.

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Fig. 26 shows the results of the human histone acetylase mRNA expression profiling performed by RT PCR

Fig. 27 shows the results of the human histone acetylase mRNA expression profiling performed by Taqman (normalized to 18S RNA)

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Fig. 27 shows the results of the human histone acetylase mRNA expression profiling performed by Taqman (copy number).

DETAILED DESCRIPTION OF THE INVENTION

20 The invention relates to an isolated polynucleotide encoding a histone deacetylase polypeptide and being selected from the group consisting of:

a) a polynucleotide encoding a histone deacetylase polypeptide comprising an amino acid sequence selected from the group consisting of:

25

amino acid sequences which are at least about 52% identical to the amino acid sequence shown in SEQ ID NO: 2; and the amino acid sequence shown in SEQ ID NO: 2;

30

b) a polynucleotide comprising the sequence of SEQ ID NO: 1;

- c) a polynucleotide which hybridizes under stringent conditions to a polynucleotide specified in (a) and (b);
- d) a polynucleotide the sequence of which deviates from the polynucleotide sequences specified in (a) to (c) due to the degeneration of the genetic code; and
- e) a polynucleotide which represents a fragment, derivative or allelic variation of a polynucleotide sequence specified in (a) to (d).

10

Furthermore, it has been discovered by the present applicant that a novel histone deacetylase, particularly a human histone deacetylase, is a discovery of the present invention. Human histone deacetylase comprises the amino acid sequence shown in SEQ ID NO: 2. A coding sequence for human histone deacetylase is shown in SEQ ID NO: 1. Related ESTs (SEQ ID NOS:5-21) are expressed in squamous cell carcinoma, anaplastic oligodendroglioma, kidney, pooled human melanocytes, fetal heart, pregnant uterus, germinal center B cells, chronic lymphatic leukemia, heart, colon, kidney tumors, adenocarcinoma, breast tumors, fetal liver and spleen, and schizophrenic brain S-11 frontal lobe.

20

Human histone deacetylase is 42% identical over 354 amino acids to the protein identified with SwissProt Accession No. P56523 and annotated as "HISTONE DEACETYLASE CLR3" (Fig. 22). Human histone deacetylase also is 51% identical over 362 and 395 amino acids to the human protein identified with trembl Accession No. AF132609 and annotated as "histone deacetylase 6" (Fig. 23).

25

Human histone deacetylase of the invention is expected to be useful for the same purposes as previously identified histone deacetylase enzymes. Human histone deacetylase is believed to be useful in therapeutic methods to treat disorders such as cancer. Human histone deacetylase also can be used to screen for human histone deacetylase activators and inhibitors.

30

Polypeptides

Human histone deacetylase polypeptides according to the invention comprise at least
5 6, 10, 15, 20, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, 350, 375,
400, 425, 450, 475, 500, 525, 550, 575, 600, 625, 650, or 670 contiguous amino
acids selected from the amino acid sequence shown in SEQ ID NO: 2 or a
biologically active variant thereof, as defined below. A histone deacetylase poly-
peptide of the invention therefore can be a portion of a histone deacetylase protein, a
10 full-length histone deacetylase protein, or a fusion protein comprising all or a portion
of a histone deacetylase protein.

Biologically Active Variants

15 Human histone deacetylase polypeptide variants which are biologically active, *e.g.*,
retain a histone deacetylase activity, also are histone deacetylase polypeptides.
Preferably, naturally or non-naturally occurring histone deacetylase polypeptide
variants have amino acid sequences which are at least about 52, 55, 60, 65, or 70,
preferably about 75, 80, 85, 90, 96, 96, or 98% identical to the amino acid sequence
20 shown in SEQ ID NO: 2 or a fragment thereof. Percent identity between a putative
histone deacetylase polypeptide variant and an amino acid sequence of SEQ ID NO:
2 is determined using the Blast2 alignment program (Blosum62, Expect 10, standard
genetic codes).

25 Variations in percent identity can be due, for example, to amino acid substitutions,
insertions, or deletions. Amino acid substitutions are defined as one for one amino
acid replacements. They are conservative in nature when the substituted amino acid
has similar structural and/or chemical properties. Examples of conservative
replacements are substitution of a leucine with an isoleucine or valine, an aspartate
30 with a glutamate, or a threonine with a serine.

Amino acid insertions or deletions are changes to or within an amino acid sequence. They typically fall in the range of about 1 to 5 amino acids. Guidance in determining which amino acid residues can be substituted, inserted, or deleted without abolishing biological or immunological activity of a histone deacetylase polypeptide can be found using computer programs well known in the art, such as DNASTAR software. Whether an amino acid change results in a biologically active histone deacetylase polypeptide can readily be determined by assaying for histone deacetylase activity, as described for example, in the specific examples, below.

10 Fusion Proteins

Fusion proteins are useful for generating antibodies against histone deacetylase polypeptide amino acid sequences and for use in various assay systems. For example, fusion proteins can be used to identify proteins which interact with portions of a histone deacetylase polypeptide. Protein affinity chromatography or library-based assays for protein-protein interactions, such as the yeast two-hybrid or phage display systems, can be used for this purpose. Such methods are well known in the art and also can be used as drug screens.

20 A histone deacetylase polypeptide fusion protein comprises two polypeptide segments fused together by means of a peptide bond. The first polypeptide segment comprises at least 6, 10, 15, 20, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, 500, 525, 550, 575, 600, 625, 650, or 670 contiguous amino acids of SEQ ID NO: 2 or of a biologically active variant, such as those described above. The first polypeptide segment also can comprise full-length histone deacetylase protein.

The second polypeptide segment can be a full-length protein or a protein fragment. Proteins commonly used in fusion protein construction include β -galactosidase, β -glucuronidase, green fluorescent protein (GFP), autofluorescent proteins, including blue fluorescent protein (BFP), glutathione-S-transferase (GST), luciferase, horse-

radish peroxidase (HRP), and chloramphenicol acetyltransferase (CAT). Additionally, epitope tags are used in fusion protein constructions, including histidine (His) tags, FLAG tags, influenza hemagglutinin (HA) tags, Myc tags, VSV-G tags, and thioredoxin (Trx) tags. Other fusion constructions can include maltose binding
5 protein (MBP), S-tag, Lex a DNA binding domain (DBD) fusions, GAL4 DNA binding domain fusions, and herpes simplex virus (HSV) BP16 protein fusions. A fusion protein also can be engineered to contain a cleavage site located between the histone deacetylase polypeptide-encoding sequence and the heterologous protein sequence, so that the histone deacetylase polypeptide can be cleaved and purified
10 away from the heterologous moiety.

A fusion protein can be synthesized chemically, as is known in the art. Preferably, a fusion protein is produced by covalently linking two polypeptide segments or by standard procedures in the art of molecular biology. Recombinant DNA methods can
15 be used to prepare fusion proteins, for example, by making a DNA construct which comprises coding sequences selected from the complement of SEQ ID NO: 1 in proper reading frame with nucleotides encoding the second polypeptide segment and expressing the DNA construct in a host cell, as is known in the art. Many kits for constructing fusion proteins are available from companies such as Promega
20 Corporation (Madison, WI), Stratagene (La Jolla, CA), CLONTECH (Mountain View, CA), Santa Cruz Biotechnology (Santa Cruz, CA), MBL International Corporation (MIC; Watertown, MA), and Quantum Biotechnologies (Montreal, Canada; 1-888-DNA-KITS).

25 Identification of Species Homologs

Species homologs of human histone deacetylase polypeptide can be obtained using histone deacetylase polypeptide polynucleotides (described below) to make suitable probes or primers for screening cDNA expression libraries from other species, such
30 as mice, monkeys, or yeast, identifying cDNAs which encode homologs of histone deacetylase polypeptide, and expressing the cDNAs as is known in the art.

Polynucleotides

A histone deacetylase polynucleotide can be single- or double-stranded and comprises a coding sequence or the complement of a coding sequence for a histone deacetylase polypeptide. A coding sequence for human histone deacetylase is shown in SEQ ID NO: 1.

Degenerate nucleotide sequences encoding human histone deacetylase polypeptides, as well as homologous nucleotide sequences which are at least about 50, 55, 60, 65, 70, preferably about 75, 90, 96, or 98% identical to the nucleotide sequence shown in SEQ ID NO: 1 or its complement also are histone deacetylase polynucleotides. Percent sequence identity between the sequences of two polynucleotides is determined using computer programs such as ALIGN which employ the FASTA algorithm, using an affine gap search with a gap open penalty of -12 and a gap extension penalty of -2. Complementary DNA (cDNA) molecules, species homologs, and variants of histone deacetylase polynucleotides which encode biologically active histone deacetylase polypeptides also are histone deacetylase polynucleotides.

Identification of Polynucleotide Variants and Homologs

Variants and homologs of the histone deacetylase polynucleotides described above also are histone deacetylase polynucleotides. Typically, homologous histone deacetylase polynucleotide sequences can be identified by hybridization of candidate polynucleotides to known histone deacetylase polynucleotides under stringent conditions, as is known in the art. For example, using the following wash conditions--2X SSC (0.3 M NaCl, 0.03 M sodium citrate, pH 7.0), 0.1% SDS, room temperature twice, 30 minutes each; then 2X SSC, 0.1% SDS, 50 μ C once, 30 minutes; then 2X SSC, room temperature twice, 10 minutes each--homologous sequences can be identified which contain at most about 25-30% basepair

mismatches. More preferably, homologous nucleic acid strands contain 15-25% basepair mismatches, even more preferably 5-15% basepair mismatches.

Species homologs of the histone deacetylase polynucleotides disclosed herein also
5 can be identified by making suitable probes or primers and screening cDNA
expression libraries from other species, such as mice, monkeys, or yeast. Human
variants of histone deacetylase polynucleotides can be identified, for example, by
screening human cDNA expression libraries. It is well known that the T_m of a
double-stranded DNA decreases by 1-1.5°C with every 1% decrease in homology
10 (Bonner *et al.*, *J. Mol. Biol.* 81, 123 (1973). Variants of human histone deacetylase
polynucleotides or histone deacetylase polynucleotides of other species can therefore
be identified by hybridizing a putative homologous histone deacetylase poly-
nucleotide with a polynucleotide having a nucleotide sequence of SEQ ID NO: 1 or
the complement thereof to form a test hybrid. The melting temperature of the test
15 hybrid is compared with the melting temperature of a hybrid comprising poly-
nucleotides having perfectly complementary nucleotide sequences, and the number
or percent of basepair mismatches within the test hybrid is calculated.

Nucleotide sequences which hybridize to histone deacetylase polynucleotides or their
20 complements following stringent hybridization and/or wash conditions also are
histone deacetylase polynucleotides. Stringent wash conditions are well known and
understood in the art and are disclosed, for example, in Sambrook *et al.*, MOLECULAR
CLONING: A LABORATORY MANUAL, 2d ed., 1989, at pages 9.50-9.51.

25 Typically, for stringent hybridization conditions a combination of temperature and
salt concentration should be chosen that is approximately 12-20°C below the
calculated T_m of the hybrid under study. The T_m of a hybrid between a histone
deacetylase polynucleotide having a nucleotide sequence shown in SEQ ID NO: 1 or
the complement thereof and a polynucleotide sequence which is at least about 50,
30 preferably about 75, 90, 96, or 98% identical to one of those nucleotide sequences

- 14 -

can be calculated, for example, using the equation of Bolton and McCarthy, *Proc. Natl. Acad. Sci. U.S.A.* 48, 1390 (1962):

$$T_m = 81.5^{\circ}\text{C} - 16.6(\log_{10}[\text{Na}^+]) + 0.41(\%G + C) - 0.63(\%\text{formamide}) - 600/l,$$

5 where l = the length of the hybrid in basepairs.

Stringent wash conditions include, for example, 4X SSC at 65°C, or 50% formamide, 4X SSC at 42°C, or 0.5X SSC, 0.1% SDS at 65°C. Highly stringent wash conditions include, for example, 0.2X SSC at 65°C.

10

Preparation of Polynucleotides

A histone deacetylase polynucleotide can be isolated free of other cellular components such as membrane components, proteins, and lipids. Polynucleotides can be made by a cell and isolated using standard nucleic acid purification techniques, or synthesized using an amplification technique, such as the polymerase chain reaction (PCR), or by using an automatic synthesizer. Methods for isolating polynucleotides are routine and are known in the art. Any such technique for obtaining a polynucleotide can be used to obtain isolated histone deacetylase polynucleotides. For example, restriction enzymes and probes can be used to isolate polynucleotide fragments which comprises histone deacetylase nucleotide sequences. Isolated polynucleotides are in preparations which are free or at least 70, 80, or 90% free of other molecules.

25 Human histone deacetylase cDNA molecules can be made with standard molecular biology techniques, using histone deacetylase mRNA as a template. Human histone deacetylase cDNA molecules can thereafter be replicated using molecular biology techniques known in the art and disclosed in manuals such as Sambrook *et al.* (1989). An amplification technique, such as PCR, can be used to obtain additional copies of polynucleotides of the invention, using either human genomic DNA or cDNA as a template.

30

Alternatively, synthetic chemistry techniques can be used to synthesize histone deacetylase polynucleotides. The degeneracy of the genetic code allows alternate nucleotide sequences to be synthesized which will encode a histone deacetylase polypeptide having, for example, an amino acid sequence shown in SEQ ID NO: 2 or a biologically active variant thereof.

Extending Polynucleotides

Various PCR-based methods can be used to extend the nucleic acid sequences disclosed herein to detect upstream sequences such as promoters and regulatory elements. For example, restriction-site PCR uses universal primers to retrieve unknown sequence adjacent to a known locus (Sarkar, *PCR Methods Applic.* 2, 318-322, 1993). Genomic DNA is first amplified in the presence of a primer to a linker sequence and a primer specific to the known region. The amplified sequences are then subjected to a second round of PCR with the same linker primer and another specific primer internal to the first one. Products of each round of PCR are transcribed with an appropriate RNA polymerase and sequenced using reverse transcriptase.

Inverse PCR also can be used to amplify or extend sequences using divergent primers based on a known region (Triglia *et al.*, *Nucleic Acids Res.* 16, 8186, 1988). Primers can be designed using commercially available software, such as OLIGO 4.06 Primer Analysis software (National Biosciences Inc., Plymouth, Minn.), to be 22-30 nucleotides in length, to have a GC content of 50% or more, and to anneal to the target sequence at temperatures about 68-72°C. The method uses several restriction enzymes to generate a suitable fragment in the known region of a gene. The fragment is then circularized by intramolecular ligation and used as a PCR template.

Another method which can be used is capture PCR, which involves PCR amplification of DNA fragments adjacent to a known sequence in human and yeast

artificial chromosome DNA (Lagerstrom *et al.*, *PCR Methods Applic. 1*, 111-119, 1991). In this method, multiple restriction enzyme digestions and ligations also can be used to place an engineered double-stranded sequence into an unknown fragment of the DNA molecule before performing PCR.

5

Another method which can be used to retrieve unknown sequences is that of Parker *et al.*, *Nucleic Acids Res. 19*, 3055-3060, 1991). Additionally, PCR, nested primers, and PROMOTERFINDER libraries (CLONTECH, Palo Alto, Calif.) can be used to walk genomic DNA (CLONTECH, Palo Alto, Calif.). This process avoids the need to screen libraries and is useful in finding intron/exon junctions.

10

When screening for full-length cDNAs, it is preferable to use libraries that have been size-selected to include larger cDNAs. Randomly-primed libraries are preferable, in that they will contain more sequences which contain the 5' regions of genes. Use of a randomly primed library may be especially preferable for situations in which an oligo d(T) library does not yield a full-length cDNA. Genomic libraries can be useful for extension of sequence into 5' non-transcribed regulatory regions.

15

Commercially available capillary electrophoresis systems can be used to analyze the size or confirm the nucleotide sequence of PCR or sequencing products. For example, capillary sequencing can employ flowable polymers for electrophoretic separation, four different fluorescent dyes (one for each nucleotide) which are laser activated, and detection of the emitted wavelengths by a charge coupled device camera. Output/light intensity can be converted to electrical signal using appropriate software (*e.g.* GENOTYPER and Sequence NAVIGATOR, Perkin Elmer), and the entire process from loading of samples to computer analysis and electronic data display can be computer controlled. Capillary electrophoresis is especially preferable for the sequencing of small pieces of DNA which might be present in limited amounts in a particular sample.

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Obtaining Polypeptides

Human histone deacetylase polypeptides can be obtained, for example, by purification from human cells, by expression of histone deacetylase polynucleotides, or by
5 direct chemical synthesis.

Protein Purification

Human histone deacetylase polypeptides can be purified from any cell which
10 expresses the enzyme, including host cells which have been transfected with histone deacetylase expression constructs. A purified histone deacetylase polypeptide is separated from other compounds which normally associate with the histone deacetylase polypeptide in the cell, such as certain proteins, carbohydrates, or lipids, using methods well-known in the art. Such methods include, but are not limited to,
15 size exclusion chromatography, ammonium sulfate fractionation, ion exchange chromatography, affinity chromatography, and preparative gel electrophoresis. A preparation of purified histone deacetylase polypeptides is at least 80% pure; preferably, the preparations are 90%, 95%, or 99% pure. Purity of the preparations can be assessed by any means known in the art, such as SDS-polyacrylamide gel
20 electrophoresis.

Expression of Polynucleotides

To express a histone deacetylase polynucleotide, the polynucleotide can be inserted
25 into an expression vector which contains the necessary elements for the transcription and translation of the inserted coding sequence. Methods which are well known to those skilled in the art can be used to construct expression vectors containing sequences encoding histone deacetylase polypeptides and appropriate transcriptional and translational control elements. These methods include *in vitro* recombinant
30 DNA techniques, synthetic techniques, and *in vivo* genetic recombination. Such techniques are described, for example, in Sambrook *et al.* (1989) and in Ausubel *et*

al., CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, John Wiley & Sons, New York, N.Y., 1989.

5 A variety of expression vector/host systems can be utilized to contain and express sequences encoding a histone deacetylase polypeptide. These include, but are not limited to, microorganisms, such as bacteria transformed with recombinant bacteriophage, plasmid, or cosmid DNA expression vectors; yeast transformed with yeast expression vectors, insect cell systems infected with virus expression vectors (e.g., baculovirus), plant cell systems transformed with virus expression vectors (e.g.,
10 cauliflower mosaic virus, CaMV; tobacco mosaic virus, TMV) or with bacterial expression vectors (e.g., Ti or pBR322 plasmids), or animal cell systems.

The control elements or regulatory sequences are those non-translated regions of the vector -- enhancers, promoters, 5' and 3' untranslated regions -- which interact with
15 host cellular proteins to carry out transcription and translation. Such elements can vary in their strength and specificity. Depending on the vector system and host utilized, any number of suitable transcription and translation elements, including constitutive and inducible promoters, can be used. For example, when cloning in bacterial systems, inducible promoters such as the hybrid lacZ promoter of the
20 BLUESCRIPT phagemid (Stratagene, LaJolla, Calif.) or pSPORT1 plasmid (Life Technologies) and the like can be used. The baculovirus polyhedrin promoter can be used in insect cells. Promoters or enhancers derived from the genomes of plant cells (e.g., heat shock, RUBISCO, and storage protein genes) or from plant viruses (e.g., viral promoters or leader sequences) can be cloned into the vector. In mammalian
25 cell systems, promoters from mammalian genes or from mammalian viruses are preferable. If it is necessary to generate a cell line that contains multiple copies of a nucleotide sequence encoding a histone deacetylase polypeptide, vectors based on SV40 or EBV can be used with an appropriate selectable marker.

Bacterial and Yeast Expression Systems

In bacterial systems, a number of expression vectors can be selected depending upon the use intended for the histone deacetylase polypeptide. For example, when a large
5 quantity of a histone deacetylase polypeptide is needed for the induction of anti-
bodies, vectors which direct high level expression of fusion proteins that are readily
purified can be used. Such vectors include, but are not limited to, multifunctional *E.*
coli cloning and expression vectors such as BLUESCRIPT (Stratagene). In a
10 BLUESCRIPT vector, a sequence encoding the histone deacetylase polypeptide can
be ligated into the vector in frame with sequences for the amino-terminal Met and the
subsequent 7 residues of β -galactosidase so that a hybrid protein is produced. pIN
vectors (Van Heeke & Schuster, *J. Biol. Chem.* 264, 5503-5509, 1989) or pGEX
vectors (Promega, Madison, Wis.) also can be used to express foreign polypeptides
as fusion proteins with glutathione S-transferase (GST). In general, such fusion
15 proteins are soluble and can easily be purified from lysed cells by adsorption to
glutathione-agarose beads followed by elution in the presence of free glutathione.
Proteins made in such systems can be designed to include heparin, thrombin, or
factor Xa protease cleavage sites so that the cloned polypeptide of interest can be
released from the GST moiety at will.

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In the yeast *Saccharomyces cerevisiae*, a number of vectors containing constitutive
or inducible promoters such as alpha factor, alcohol oxidase, and PGH can be used.
For reviews, see Ausubel *et al.* (1989) and Grant *et al.*, *Methods Enzymol.* 153, 516-
544, 1987.

25

Plant and Insect Expression Systems

If plant expression vectors are used, the expression of sequences encoding histone
deacetylase polypeptides can be driven by any of a number of promoters. For
30 example, viral promoters such as the 35S and 19S promoters of CaMV can be used
alone or in combination with the omega leader sequence from TMV (Takamatsu,

5 *EMBO J.* 6, 307-311, 1987). Alternatively, plant promoters such as the small subunit of RUBISCO or heat shock promoters can be used (Coruzzi *et al.*, *EMBO J.* 3, 1671-1680, 1984; Broglie *et al.*, *Science* 224, 838-843, 1984; Winter *et al.*, *Results Probl. Cell Differ.* 17, 85-105, 1991). These constructs can be introduced into plant cells by direct DNA transformation or by pathogen-mediated transfection. Such techniques are described in a number of generally available reviews (*e.g.*, Hobbs or Murray, in MCGRAW HILL YEARBOOK OF SCIENCE AND TECHNOLOGY, McGraw Hill, New York, N.Y., pp. 191-196, 1992).

10 An insect system also can be used to express a histone deacetylase polypeptide. For example, in one such system *Autographa californica* nuclear polyhedrosis virus (AcNPV) is used as a vector to express foreign genes in *Spodoptera frugiperda* cells or in *Trichoplusia* larvae. Sequences encoding histone deacetylase polypeptides can be cloned into a non-essential region of the virus, such as the polyhedrin gene, and
15 placed under control of the polyhedrin promoter. Successful insertion of histone deacetylase polypeptides will render the polyhedrin gene inactive and produce recombinant virus lacking coat protein. The recombinant viruses can then be used to infect *S. frugiperda* cells or *Trichoplusia* larvae in which histone deacetylase polypeptides can be expressed (Engelhard *et al.*, *Proc. Nat. Acad. Sci.* 91, 3224-
20 3227, 1994).

Mammalian Expression Systems

25 A number of viral-based expression systems can be used to express histone deacetylase polypeptides in mammalian host cells. For example, if an adenovirus is used as an expression vector, sequences encoding histone deacetylase polypeptides can be ligated into an adenovirus transcription/translation complex comprising the late promoter and tripartite leader sequence. Insertion in a non-essential E1 or E3 region of the viral genome can be used to obtain a viable virus which is capable of
30 expressing a histone deacetylase polypeptide in infected host cells (Logan & Shenk, *Proc. Natl. Acad. Sci.* 81, 3655-3659, 1984). If desired, transcription enhancers, such

as the Rous sarcoma virus (RSV) enhancer, can be used to increase expression in mammalian host cells.

5 Human artificial chromosomes (HACs) also can be used to deliver larger fragments of DNA than can be contained and expressed in a plasmid. HACs of 6M to 10M are constructed and delivered to cells via conventional delivery methods (e.g., liposomes, polycationic amino polymers, or vesicles).

10 Specific initiation signals also can be used to achieve more efficient translation of sequences encoding histone deacetylase polypeptides. Such signals include the ATG initiation codon and adjacent sequences. In cases where sequences encoding a histone deacetylase polypeptide, its initiation codon, and upstream sequences are inserted into the appropriate expression vector, no additional transcriptional or translational control signals may be needed. However, in cases where only coding
15 sequence, or a fragment thereof, is inserted, exogenous translational control signals (including the ATG initiation codon) should be provided. The initiation codon should be in the correct reading frame to ensure translation of the entire insert. Exogenous translational elements and initiation codons can be of various origins, both natural and synthetic. The efficiency of expression can be enhanced by the
20 inclusion of enhancers which are appropriate for the particular cell system which is used (see Scharf *et al.*, *Results Probl. Cell Differ.* 20, 125-162, 1994).

Host Cells

25 A host cell strain can be chosen for its ability to modulate the expression of the inserted sequences or to process the expressed histone deacetylase polypeptide in the desired fashion. Such modifications of the polypeptide include, but are not limited to, acetylation, carboxylation, glycosylation, phosphorylation, lipidation, and acylation. Post-translational processing which cleaves a "prepro" form of the poly-
30 peptide also can be used to facilitate correct insertion, folding and/or function. Different host cells which have specific cellular machinery and characteristic

mechanisms for post-translational activities (e.g., CHO, HeLa, MDCK, HEK293, and WI38), are available from the American Type Culture Collection (ATCC; 10801 University Boulevard, Manassas, VA 20110-2209) and can be chosen to ensure the correct modification and processing of the foreign protein.

5

Stable expression is preferred for long-term, high-yield production of recombinant proteins. For example, cell lines which stably express histone deacetylase polypeptides can be transformed using expression vectors which can contain viral origins of replication and/or endogenous expression elements and a selectable marker gene on the same or on a separate vector. Following the introduction of the vector, cells can be allowed to grow for 1-2 days in an enriched medium before they are switched to a selective medium. The purpose of the selectable marker is to confer resistance to selection, and its presence allows growth and recovery of cells which successfully express the introduced histone deacetylase sequences. Resistant clones of stably transformed cells can be proliferated using tissue culture techniques appropriate to the cell type. See, for example, ANIMAL CELL CULTURE, R.I. Freshney, ed., 1986.

15

Any number of selection systems can be used to recover transformed cell lines.

These include, but are not limited to, the herpes simplex virus thymidine kinase (Wigler *et al.*, *Cell* 11, 223-32, 1977) and adenine phosphoribosyltransferase (Lowy *et al.*, *Cell* 22, 817-23, 1980) genes which can be employed in *tk* or *aprt* cells, respectively. Also, antimetabolite, antibiotic, or herbicide resistance can be used as the basis for selection. For example, *dhfr* confers resistance to methotrexate (Wigler *et al.*, *Proc. Natl. Acad. Sci.* 77, 3567-70, 1980), *npt* confers resistance to the aminoglycosides, neomycin and G-418 (Colbere-Garapin *et al.*, *J. Mol. Biol.* 150, 1-14, 1981), and *als* and *pat* confer resistance to chlorsulfuron and phosphinotricin acetyltransferase, respectively (Murray, 1992, *supra*). Additional selectable genes have been described. For example, *trpB* allows cells to utilize indole in place of tryptophan, or *hisD*, which allows cells to utilize histinol in place of histidine (Hartman & Mulligan, *Proc. Natl. Acad. Sci.* 85, 8047-51, 1988). Visible markers

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such as anthocyanins, β -glucuronidase and its substrate GUS, and luciferase and its substrate luciferin, can be used to identify transformants and to quantify the amount of transient or stable protein expression attributable to a specific vector system (Rhodes *et al.*, *Methods Mol. Biol.* 55, 121-131, 1995).

5

Detecting Expression

Although the presence of marker gene expression suggests that the histone deacetylase polynucleotide is also present, its presence and expression may need to be confirmed. For example, if a sequence encoding a histone deacetylase polypeptide is inserted within a marker gene sequence, transformed cells containing sequences which encode a histone deacetylase polypeptide can be identified by the absence of marker gene function. Alternatively, a marker gene can be placed in tandem with a sequence encoding a histone deacetylase polypeptide under the control of a single promoter. Expression of the marker gene in response to induction or selection usually indicates expression of the histone deacetylase polynucleotide.

Alternatively, host cells which contain a histone deacetylase polynucleotide and which express a histone deacetylase polypeptide can be identified by a variety of procedures known to those of skill in the art. These procedures include, but are not limited to, DNA-DNA or DNA-RNA hybridizations and protein bioassay or immunoassay techniques which include membrane, solution, or chip-based technologies for the detection and/or quantification of nucleic acid or protein. For example, the presence of a polynucleotide sequence encoding a histone deacetylase polypeptide can be detected by DNA-DNA or DNA-RNA hybridization or amplification using probes or fragments or fragments of polynucleotides encoding a histone deacetylase polypeptide. Nucleic acid amplification-based assays involve the use of oligonucleotides selected from sequences encoding a histone deacetylase polypeptide to detect transformants which contain a histone deacetylase polynucleotide.

30

A variety of protocols for detecting and measuring the expression of a histone deacetylase polypeptide, using either polyclonal or monoclonal antibodies specific for the polypeptide, are known in the art. Examples include enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), and fluorescence activated cell sorting (FACS). A two-site, monoclonal-based immunoassay using monoclonal antibodies reactive to two non-interfering epitopes on a histone deacetylase polypeptide can be used, or a competitive binding assay can be employed. These and other assays are described in Hampton *et al.*, SEROLOGICAL METHODS: A LABORATORY MANUAL, APS Press, St. Paul, Minn., 1990) and Maddox *et al.*, *J. Exp. Med.* 158, 1211-1216, 1983).

A wide variety of labels and conjugation techniques are known by those skilled in the art and can be used in various nucleic acid and amino acid assays. Means for producing labeled hybridization or PCR probes for detecting sequences related to polynucleotides encoding histone deacetylase polypeptides include oligolabeling, nick translation, end-labeling, or PCR amplification using a labeled nucleotide. Alternatively, sequences encoding a histone deacetylase polypeptide can be cloned into a vector for the production of an mRNA probe. Such vectors are known in the art, are commercially available, and can be used to synthesize RNA probes *in vitro* by addition of labeled nucleotides and an appropriate RNA polymerase such as T7, T3, or SP6. These procedures can be conducted using a variety of commercially available kits (Amersham Pharmacia Biotech, Promega, and US Biochemical). Suitable reporter molecules or labels which can be used for ease of detection include radionuclides, enzymes, and fluorescent, chemiluminescent, or chromogenic agents, as well as substrates, cofactors, inhibitors, magnetic particles, and the like.

Expression and Purification of Polypeptides

Host cells transformed with nucleotide sequences encoding a histone deacetylase polypeptide can be cultured under conditions suitable for the expression and recovery of the protein from cell culture. The polypeptide produced by a transformed cell can

be secreted or contained intracellularly depending on the sequence and/or the vector used. As will be understood by those of skill in the art, expression vectors containing polynucleotides which encode histone deacetylase polypeptides can be designed to contain signal sequences which direct secretion of soluble histone deacetylase polypeptides through a prokaryotic or eukaryotic cell membrane or which direct the membrane insertion of membrane-bound histone deacetylase polypeptide.

As discussed above, other constructions can be used to join a sequence encoding a histone deacetylase polypeptide to a nucleotide sequence encoding a polypeptide domain which will facilitate purification of soluble proteins. Such purification facilitating domains include, but are not limited to, metal chelating peptides such as histidine-tryptophan modules that allow purification on immobilized metals, protein A domains that allow purification on immobilized immunoglobulin, and the domain utilized in the FLAGS extension/affinity purification system (Immunex Corp., Seattle, Wash.). Inclusion of cleavable linker sequences such as those specific for Factor Xa or enterokinase (Invitrogen, San Diego, CA) between the purification domain and the histone deacetylase polypeptide also can be used to facilitate purification. One such expression vector provides for expression of a fusion protein containing a histone deacetylase polypeptide and 6 histidine residues preceding a thioredoxin or an enterokinase cleavage site. The histidine residues facilitate purification by IMAC (immobilized metal ion affinity chromatography, as described in Porath *et al.*, *Prot. Exp. Purif.* 3, 263-281, 1992), while the enterokinase cleavage site provides a means for purifying the histone deacetylase polypeptide from the fusion protein. Vectors which contain fusion proteins are disclosed in Kroll *et al.*, *DNA Cell Biol.* 12, 441-453, 1993.

Chemical Synthesis

Sequences encoding a histone deacetylase polypeptide can be synthesized, in whole or in part, using chemical methods well known in the art (see Caruthers *et al.*, *Nucl. Acids Res. Symp. Ser.* 215-223, 1980; Horn *et al.* *Nucl. Acids Res. Symp. Ser.* 225-

232, 1980). Alternatively, a histone deacetylase polypeptide itself can be produced using chemical methods to synthesize its amino acid sequence, such as by direct peptide synthesis using solid-phase techniques (Merrifield, *J. Am. Chem. Soc.* 85, 2149-2154, 1963; Roberge *et al.*, *Science* 269, 202-204, 1995). Protein synthesis can be performed using manual techniques or by automation. Automated synthesis can be achieved, for example, using Applied Biosystems 431A Peptide Synthesizer (Perkin Elmer). Optionally, fragments of histone deacetylase polypeptides can be separately synthesized and combined using chemical methods to produce a full-length molecule.

The newly synthesized peptide can be substantially purified by preparative high performance liquid chromatography (*e.g.*, Creighton, *PROTEINS: STRUCTURES AND MOLECULAR PRINCIPLES*, WH Freeman and Co., New York, N.Y., 1983). The composition of a synthetic histone deacetylase polypeptide can be confirmed by amino acid analysis or sequencing (*e.g.*, the Edman degradation procedure; *see* Creighton, *supra*). Additionally, any portion of the amino acid sequence of the histone deacetylase polypeptide can be altered during direct synthesis and/or combined using chemical methods with sequences from other proteins to produce a variant polypeptide or a fusion protein.

Production of Altered Polypeptides

As will be understood by those of skill in the art, it may be advantageous to produce histone deacetylase polypeptide-encoding nucleotide sequences possessing non-naturally occurring codons. For example, codons preferred by a particular prokaryotic or eukaryotic host can be selected to increase the rate of protein expression or to produce an RNA transcript having desirable properties, such as a half-life which is longer than that of a transcript generated from the naturally occurring sequence.

The nucleotide sequences disclosed herein can be engineered using methods generally known in the art to alter histone deacetylase polypeptide-encoding

sequences for a variety of reasons, including but not limited to, alterations which modify the cloning, processing, and/or expression of the polypeptide or mRNA product. DNA shuffling by random fragmentation and PCR reassembly of gene fragments and synthetic oligonucleotides can be used to engineer the nucleotide sequences. For example, site-directed mutagenesis can be used to insert new restriction sites, alter glycosylation patterns, change codon preference, produce splice variants, introduce mutations, and so forth.

Antibodies

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Any type of antibody known in the art can be generated to bind specifically to an epitope of a histone deacetylase polypeptide. "Antibody" as used herein includes intact immunoglobulin molecules, as well as fragments thereof, such as Fab, F(ab')₂, and Fv, which are capable of binding an epitope of a histone deacetylase polypeptide. Typically, at least 6, 8, 10, or 12 contiguous amino acids are required to form an epitope. However, epitopes which involve non-contiguous amino acids may require more, e.g., at least 15, 25, or 50 amino acids.

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An antibody which specifically binds to an epitope of a histone deacetylase polypeptide can be used therapeutically, as well as in immunochemical assays, such as Western blots, ELISAs, radioimmunoassays, immunohistochemical assays, immunoprecipitations, or other immunochemical assays known in the art. Various immunoassays can be used to identify antibodies having the desired specificity. Numerous protocols for competitive binding or immunoradiometric assays are well known in the art. Such immunoassays typically involve the measurement of complex formation between an immunogen and an antibody which specifically binds to the immunogen.

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Typically, an antibody which specifically binds to a histone deacetylase polypeptide provides a detection signal at least 5-, 10-, or 20-fold higher than a detection signal provided with other proteins when used in an immunochemical assay. Preferably,

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antibodies which specifically bind to histone acetylase polypeptides do not detect other proteins in immunochemical assays and can immunoprecipitate a histone deacetylase polypeptide from solution.

5 Human histone deacetylase polypeptides can be used to immunize a mammal, such as a mouse, rat, rabbit, guinea pig, monkey, or human, to produce polyclonal antibodies. If desired, a histone deacetylase polypeptide can be conjugated to a carrier protein, such as bovine serum albumin, thyroglobulin, and keyhole limpet hemocyanin. Depending on the host species, various adjuvants can be used to
10 increase the immunological response. Such adjuvants include, but are not limited to, Freund's adjuvant, mineral gels (e.g., aluminum hydroxide), and surface active substances (e.g. lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions, keyhole limpet hemocyanin, and dinitrophenol). Among adjuvants used in humans, BCG (*bacilli Calmette-Guerin*) and *Corynebacterium parvum* are especially useful.

15 Monoclonal antibodies which specifically bind to a histone deacetylase polypeptide can be prepared using any technique which provides for the production of antibody molecules by continuous cell lines in culture. These techniques include, but are not limited to, the hybridoma technique, the human B-cell hybridoma technique, and the
20 EBV-hybridoma technique (Kohler *et al.*, *Nature* 256, 495-497, 1985; Kozbor *et al.*, *J. Immunol. Methods* 81, 31-42, 1985; Cote *et al.*, *Proc. Natl. Acad. Sci.* 80, 2026-2030, 1983; Cole *et al.*, *Mol. Cell Biol.* 62, 109-120, 1984).

In addition, techniques developed for the production of "chimeric antibodies," the
25 splicing of mouse antibody genes to human antibody genes to obtain a molecule with appropriate antigen specificity and biological activity, can be used (Morrison *et al.*, *Proc. Natl. Acad. Sci.* 81, 6851-6855, 1984; Neuberger *et al.*, *Nature* 312, 604-608, 1984; Takeda *et al.*, *Nature* 314, 452-454, 1985). Monoclonal and other antibodies also can be "humanized" to prevent a patient from mounting an immune response
30 against the antibody when it is used therapeutically. Such antibodies may be sufficiently similar in sequence to human antibodies to be used directly in therapy or

may require alteration of a few key residues. Sequence differences between rodent antibodies and human sequences can be minimized by replacing residues which differ from those in the human sequences by site directed mutagenesis of individual residues or by grating of entire complementarity determining regions. Alternatively,
5 humanized antibodies can be produced using recombinant methods, as described in GB2188638B. Antibodies which specifically bind to a histone deacetylase polypeptide can contain antigen binding sites which are either partially or fully humanized, as disclosed in U.S. 5,565,332.

10 Alternatively, techniques described for the production of single chain antibodies can be adapted using methods known in the art to produce single chain antibodies which specifically bind to histone deacetylase polypeptides. Antibodies with related specificity, but of distinct idiotypic composition, can be generated by chain shuffling from random combinatorial immunoglobulin libraries (Burton, *Proc. Natl. Acad. Sci.*
15 88, 11120-23, 1991).

Single-chain antibodies also can be constructed using a DNA amplification method, such as PCR, using hybridoma cDNA as a template (Thirion *et al.*, 1996, *Eur. J. Cancer Prev.* 5, 507-11). Single-chain antibodies can be mono- or bispecific, and
20 can be bivalent or tetravalent. Construction of tetravalent, bispecific single-chain antibodies is taught, for example, in Coloma & Morrison, 1997, *Nat. Biotechnol.* 15, 159-63. Construction of bivalent, bispecific single-chain antibodies is taught in Mallender & Voss, 1994, *J. Biol. Chem.* 269, 199-206.

25 A nucleotide sequence encoding a single-chain antibody can be constructed using manual or automated nucleotide synthesis, cloned into an expression construct using standard recombinant DNA methods, and introduced into a cell to express the coding sequence, as described below. Alternatively, single-chain antibodies can be produced directly using, for example, filamentous phage technology (Verhaar *et al.*,
30 1995, *Int. J. Cancer* 61, 497-501; Nicholls *et al.*, 1993, *J. Immunol. Meth.* 165, 81-91).

Antibodies which specifically bind to histone deacetylase polypeptides also can be produced by inducing *in vivo* production in the lymphocyte population or by screening immunoglobulin libraries or panels of highly specific binding reagents as disclosed in the literature (Orlandi *et al.*, *Proc. Natl. Acad. Sci.* 86, 3833-3837, 1989; Winter *et al.*, *Nature* 349, 293-299, 1991).

Other types of antibodies can be constructed and used therapeutically in methods of the invention. For example, chimeric antibodies can be constructed as disclosed in WO 93/03151. Binding proteins which are derived from immunoglobulins and which are multivalent and multispecific, such as the "diabodies" described in WO 94/13804, also can be prepared.

Antibodies according to the invention can be purified by methods well known in the art. For example, antibodies can be affinity purified by passage over a column to which a histone deacetylase polypeptide is bound. The bound antibodies can then be eluted from the column using a buffer with a high salt concentration.

Antisense Oligonucleotides

Antisense oligonucleotides are nucleotide sequences which are complementary to a specific DNA or RNA sequence. Once introduced into a cell, the complementary nucleotides combine with natural sequences produced by the cell to form complexes and block either transcription or translation. Preferably, an antisense oligonucleotide is at least 11 nucleotides in length, but can be at least 12, 15, 20, 25, 30, 35, 40, 45, or 50 or more nucleotides long. Longer sequences also can be used. Antisense oligonucleotide molecules can be provided in a DNA construct and introduced into a cell as described above to decrease the level of histone deacetylase gene products in the cell.

Antisense oligonucleotides can be deoxyribonucleotides, ribonucleotides, or a combination of both. Oligonucleotides can be synthesized manually or by an automated synthesizer, by covalently linking the 5' end of one nucleotide with the 3' end of another nucleotide with non-phosphodiester internucleotide linkages such as alkylphosphonates, phosphorothioates, phosphorodithioates, alkylphosphonothioates, alkylphosphonates, phosphoramidates, phosphate esters, carbamates, acetamides, carboxymethyl esters, carbonates, and phosphate triesters. See Brown, *Meth. Mol. Biol.* 20, 1-8, 1994; Sonveaux, *Meth. Mol. Biol.* 26, 1-72, 1994; Uhlmann *et al.*, *Chem. Rev.* 90, 543-583, 1990.

10

Modifications of histone deacetylase gene expression can be obtained by designing antisense oligonucleotides which will form duplexes to the control, 5', or regulatory regions of the histone deacetylase gene. Oligonucleotides derived from the transcription initiation site, *e.g.*, between positions -10 and +10 from the start site, are preferred. Similarly, inhibition can be achieved using "triple helix" base-pairing methodology. Triple helix pairing is useful because it causes inhibition of the ability of the double helix to open sufficiently for the binding of polymerases, transcription factors, or chaperons. Therapeutic advances using triplex DNA have been described in the literature (*e.g.*, Gee *et al.*, in Huber & Carr, MOLECULAR AND IMMUNOLOGIC APPROACHES, Futura Publishing Co., Mt. Kisco, N.Y., 1994). An antisense oligonucleotide also can be designed to block translation of mRNA by preventing the transcript from binding to ribosomes.

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Precise complementarity is not required for successful complex formation between an antisense oligonucleotide and the complementary sequence of a histone deacetylase polynucleotide. Antisense oligonucleotides which comprise, for example, 2, 3, 4, or 5 or more stretches of contiguous nucleotides which are precisely complementary to a histone deacetylase polynucleotide, each separated by a stretch of contiguous nucleotides which are not complementary to adjacent histone deacetylase nucleotides, can provide sufficient targeting specificity for histone deacetylase mRNA. Preferably, each stretch of complementary contiguous nucleotides is at least

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4, 5, 6, 7, or 8 or more nucleotides in length. Non-complementary intervening sequences are preferably 1, 2, 3, or 4 nucleotides in length. One skilled in the art can easily use the calculated melting point of an antisense-sense pair to determine the degree of mismatching which will be tolerated between a particular antisense
5 oligonucleotide and a particular histone deacetylase polynucleotide sequence.

Antisense oligonucleotides can be modified without affecting their ability to hybridize to a histone deacetylase polynucleotide. These modifications can be internal or at one or both ends of the antisense molecule. For example, inter-
10 nucleoside phosphate linkages can be modified by adding cholesteryl or diamine moieties with varying numbers of carbon residues between the amino groups and terminal ribose. Modified bases and/or sugars, such as arabinose instead of ribose, or a 3', 5'-substituted oligonucleotide in which the 3' hydroxyl group or the 5' phosphate group are substituted, also can be employed in a modified antisense oligonucleotide.
15 These modified oligonucleotides can be prepared by methods well known in the art. See, e.g., Agrawal *et al.*, *Trends Biotechnol.* 10, 152-158, 1992; Uhlmann *et al.*, *Chem. Rev.* 90, 543-584, 1990; Uhlmann *et al.*, *Tetrahedron. Lett.* 215, 3539-3542, 1987.

20 Ribozymes

Ribozymes are RNA molecules with catalytic activity. See, e.g., Cech, *Science* 236, 1532-1539; 1987; Cech, *Ann. Rev. Biochem.* 59, 543-568; 1990, Cech, *Curr. Opin. Struct. Biol.* 2, 605-609; 1992, Couture & Stinchcomb, *Trends Genet.* 12, 510-515,
25 1996. Ribozymes can be used to inhibit gene function by cleaving an RNA sequence, as is known in the art (e.g., Haseloff *et al.*, U.S. Patent 5,641,673). The mechanism of ribozyme action involves sequence-specific hybridization of the ribozyme molecule to complementary target RNA, followed by endonucleolytic cleavage. Examples include engineered hammerhead motif ribozyme molecules that can
30 specifically and efficiently catalyze endonucleolytic cleavage of specific nucleotide sequences.

The coding sequence of a histone deacetylase polynucleotide can be used to generate ribozymes which will specifically bind to mRNA transcribed from the histone deacetylase polynucleotide. Methods of designing and constructing ribozymes which can cleave other RNA molecules in trans in a highly sequence specific manner have been developed and described in the art (*see Haseloff et al. Nature 334, 585-591, 1988*). For example, the cleavage activity of ribozymes can be targeted to specific RNAs by engineering a discrete "hybridization" region into the ribozyme. The hybridization region contains a sequence complementary to the target RNA and thus specifically hybridizes with the target (*see, for example, Gerlach et al., EP 321,201*).

Specific ribozyme cleavage sites within a histone deacetylase RNA target can be identified by scanning the target molecule for ribozyme cleavage sites which include the following sequences: GUA, GUU, and GUC. Once identified, short RNA sequences of between 15 and 20 ribonucleotides corresponding to the region of the target RNA containing the cleavage site can be evaluated for secondary structural features which may render the target inoperable. Suitability of candidate histone deacetylase RNA targets also can be evaluated by testing accessibility to hybridization with complementary oligonucleotides using ribonuclease protection assays. Longer complementary sequences can be used to increase the affinity of the hybridization sequence for the target. The hybridizing and cleavage regions of the ribozyme can be integrally related such that upon hybridizing to the target RNA through the complementary regions, the catalytic region of the ribozyme can cleave the target.

Ribozymes can be introduced into cells as part of a DNA construct. Mechanical methods, such as microinjection, liposome-mediated transfection, electroporation, or calcium phosphate precipitation, can be used to introduce a ribozyme-containing DNA construct into cells in which it is desired to decrease histone deacetylase expression. Alternatively, if it is desired that the cells stably retain the DNA construct, the construct can be supplied on a plasmid and maintained as a separate

- 34 -

element or integrated into the genome of the cells, as is known in the art. A ribozyme-encoding DNA construct can include transcriptional regulatory elements, such as a promoter element, an enhancer or UAS element, and a transcriptional terminator signal, for controlling transcription of ribozymes in the cells.

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As taught in Haseloff *et al.*, U.S. Patent 5,641,673, ribozymes can be engineered so that ribozyme expression will occur in response to factors which induce expression of a target gene. Ribozymes also can be engineered to provide an additional level of regulation, so that destruction of mRNA occurs only when both a ribozyme and a target gene are induced in the cells.

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Differentially Expressed Genes

Described herein are methods for the identification of genes whose products interact with human histone deacetylase. Such genes may represent genes which are differentially expressed in disorders including, but not limited to, cancer. Further, such genes may represent genes which are differentially regulated in response to manipulations relevant to the progression or treatment of such diseases. Additionally, such genes may have a temporally modulated expression, increased or decreased at different stages of tissue or organism development. A differentially expressed gene may also have its expression modulated under control versus experimental conditions. In addition, the human histone deacetylase gene or gene product may itself be tested for differential expression.

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The degree to which expression differs in a normal versus a diseased state need only be large enough to be visualized via standard characterization techniques such as differential display techniques. Other such standard characterization techniques by which expression differences may be visualized include but are not limited to, quantitative RT (reverse transcriptase), PCR, and Northern analysis.

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Identification of Differentially Expressed Genes

To identify differentially expressed genes total RNA or, preferably, mRNA is isolated from tissues of interest. For example, RNA samples are obtained from
5 tissues of experimental subjects and from corresponding tissues of control subjects. Any RNA isolation technique which does not select against the isolation of mRNA may be utilized for the purification of such RNA samples. See, for example, Ausubel
et al., ed., CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, John Wiley & Sons, Inc. New York, 1987-1993. Large numbers of tissue samples may readily be processed
10 using techniques well known to those of skill in the art, such as, for example, the single-step RNA isolation process of Chomczynski, U.S. Patent 4,843,155.

Transcripts within the collected RNA samples which represent RNA produced by differentially expressed genes are identified by methods well known to those of skill
15 in the art. They include, for example, differential screening (Tedder *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 85, 208-12, 1988), subtractive hybridization (Hedrick *et al.*, *Nature* 308, 149-53; Lee *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 88, 2825, 1984), and, preferably, differential display (Liang & Pardee, *Science* 257, 967-71, 1992; U.S. Patent 5,262,311).

20 The differential expression information may itself suggest relevant methods for the treatment of disorders involving the human histone deacetylase. For example, treatment may include a modulation of expression of the differentially expressed genes and/or the gene encoding the human histone deacetylase. The differential
25 expression information may indicate whether the expression or activity of the differentially expressed gene or gene product or the human histone deacetylase gene or gene product are up-regulated or down-regulated.

Screening Methods

The invention provides assays for screening test compounds which bind to or modulate the activity of a histone deacetylase polypeptide or a histone deacetylase polynucleotide. A test compound preferably binds to a histone deacetylase polypeptide or polynucleotide. More preferably, a test compound decreases or increases histone acetylase activity by at least about 10, preferably about 50, more preferably about 75, 90, or 100% relative to the absence of the test compound.

Test Compounds

Test compounds can be pharmacologic agents already known in the art or can be compounds previously unknown to have any pharmacological activity. The compounds can be naturally occurring or designed in the laboratory. They can be isolated from microorganisms, animals, or plants, and can be produced recombinantly, or synthesized by chemical methods known in the art. If desired, test compounds can be obtained using any of the numerous combinatorial library methods known in the art, including but not limited to, biological libraries, spatially addressable parallel solid phase or solution phase libraries, synthetic library methods requiring deconvolution, the "one-bead one-compound" library method, and synthetic library methods using affinity chromatography selection. The biological library approach is limited to polypeptide libraries, while the other four approaches are applicable to polypeptide, non-peptide oligomer, or small molecule libraries of compounds. See Lam, *Anticancer Drug Des.* 12, 145, 1997.

Methods for the synthesis of molecular libraries are well known in the art (see, for example, DeWitt *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 90, 6909, 1993; Erb *et al.* *Proc. Natl. Acad. Sci. U.S.A.* 91, 11422, 1994; Zuckermann *et al.*, *J. Med. Chem.* 37, 2678, 1994; Cho *et al.*, *Science* 261, 1303, 1993; Carell *et al.*, *Angew. Chem. Int. Ed. Engl.* 33, 2059, 1994; Carell *et al.*, *Angew. Chem. Int. Ed. Engl.* 33, 2061; Gallop *et al.*, *J. Med. Chem.* 37, 1233, 1994). Libraries of compounds can be presented in solution

(see, e.g., Houghten, *BioTechniques* 13, 412-421, 1992), or on beads (Lam, *Nature* 354, 82-84, 1991), chips (Fodor, *Nature* 364, 555-556, 1993), bacteria or spores (Ladner, U.S. Patent 5,223,409), plasmids (Cull *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 89, 1865-1869, 1992), or phage (Scott & Smith, *Science* 249, 386-390, 1990; Devlin, *Science* 249, 404-406, 1990); Cwirla *et al.*, *Proc. Natl. Acad. Sci.* 97, 6378-6382, 1990; Felici, *J. Mol. Biol.* 222, 301-310, 1991; and Ladner, U.S. Patent 5,223,409).

High Throughput Screening

10 Test compounds can be screened for the ability to bind to histone deacetylase polypeptides or polynucleotides or to affect histone deacetylase activity or histone deacetylase gene expression using high throughput screening. Using high throughput screening, many discrete compounds can be tested in parallel so that large numbers of test compounds can be quickly screened. The most widely established techniques
15 utilize 96-well microtiter plates. The wells of the microtiter plates typically require assay volumes that range from 50 to 500 μ l. In addition to the plates, many instruments, materials, pipettors, robotics, plate washers, and plate readers are commercially available to fit the 96-well format.

20 Alternatively, "free format assays," or assays that have no physical barrier between samples, can be used. For example, an assay using pigment cells (melanocytes) in a simple homogeneous assay for combinatorial peptide libraries is described by Jayawickreme *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 19, 1614-18 (1994). The cells are placed under agarose in petri dishes, then beads that carry combinatorial compounds
25 are placed on the surface of the agarose. The combinatorial compounds are partially released the compounds from the beads. Active compounds can be visualized as dark pigment areas because, as the compounds diffuse locally into the gel matrix, the active compounds cause the cells to change colors.

30 Another example of a free format assay is described by Chelsky, "Strategies for Screening Combinatorial Libraries: Novel and Traditional Approaches," reported at

the First Annual Conference of The Society for Biomolecular Screening in Philadelphia, Pa. (Nov. 7-10, 1995). Chelsky placed a simple homogenous enzyme assay for carbonic anhydrase inside an agarose gel such that the enzyme in the gel would cause a color change throughout the gel. Thereafter, beads carrying
5 combinatorial compounds via a photolinker were placed inside the gel and the compounds were partially released by UV-light. Compounds that inhibited the enzyme were observed as local zones of inhibition having less color change.

Yet another example is described by Salmon *et al.*, *Molecular Diversity* 2, 57-63
10 (1996). In this example, combinatorial libraries were screened for compounds that had cytotoxic effects on cancer cells growing in agar.

Another high throughput screening method is described in Beutel *et al.*, U.S. Patent 5,976,813. In this method, test samples are placed in a porous matrix. One or more
15 assay components are then placed within, on top of, or at the bottom of a matrix such as a gel, a plastic sheet, a filter, or other form of easily manipulated solid support. When samples are introduced to the porous matrix they diffuse sufficiently slowly, such that the assays can be performed without the test samples running together.

20 Binding Assays

For binding assays, the test compound is preferably a small molecule which binds to and occupies, for example, the active site of the histone deacetylase polypeptide, such that normal biological activity is prevented. Examples of such small molecules
25 include, but are not limited to, small peptides or peptide-like molecules.

In binding assays, either the test compound or the histone deacetylase polypeptide can comprise a detectable label, such as a fluorescent, radioisotopic, chemiluminescent, or enzymatic label, such as horseradish peroxidase, alkaline phosphatase,
30 or luciferase. Detection of a test compound which is bound to the histone deacetylase polypeptide can then be accomplished, for example, by direct counting of

radioemmission, by scintillation counting, or by determining conversion of an appropriate substrate to a detectable product.

Alternatively, binding of a test compound to a histone deacetylase polypeptide can be
5 determined without labeling either of the interactants. For example, a micro-
physiometer can be used to detect binding of a test compound with a histone
deacetylase polypeptide. A microphysiometer (*e.g.*, Cytosensor™) is an analytical
instrument that measures the rate at which a cell acidifies its environment using a
light-addressable potentiometric sensor (LAPS). Changes in this acidification rate
10 can be used as an indicator of the interaction between a test compound and a histone
deacetylase polypeptide (McConnell *et al.*, *Science* 257, 1906-1912, 1992).

Determining the ability of a test compound to bind to a histone deacetylase poly-
peptide also can be accomplished using a technology such as real-time Bimolecular
15 Interaction Analysis (BIA) (Sjolander & Urbaniczky, *Anal. Chem.* 63, 2338-2345,
1991, and Szabo *et al.*, *Curr. Opin. Struct. Biol.* 5, 699-705, 1995). BIA is a
technology for studying biospecific interactions in real time, without labeling any of
the interactants (*e.g.*, BIAcore™). Changes in the optical phenomenon surface
plasmon resonance (SPR) can be used as an indication of real-time reactions between
20 biological molecules.

In yet another aspect of the invention, a histone deacetylase polypeptide can be used
as a "bait protein" in a two-hybrid assay or three-hybrid assay (see, *e.g.*, U.S. Patent
5,283,317; Zervos *et al.*, *Cell* 72, 223-232, 1993; Madura *et al.*, *J. Biol. Chem.* 268,
25 12046-12054, 1993; Bartel *et al.*, *BioTechniques* 14, 920-924, 1993; Iwabuchi *et al.*,
Oncogene 8, 1693-1696, 1993; and Brent W094/10300), to identify other proteins
which bind to or interact with the histone deacetylase polypeptide and modulate its
activity.

30 The two-hybrid system is based on the modular nature of most transcription factors,
which consist of separable DNA-binding and activation domains. Briefly, the assay

utilizes two different DNA constructs. For example, in one construct, polynucleotide encoding a histone deacetylase polypeptide can be fused to a polynucleotide encoding the DNA binding domain of a known transcription factor (e.g., GAL-4). In the other construct a DNA sequence that encodes an unidentified protein ("prey" or "sample") can be fused to a polynucleotide that codes for the activation domain of the known transcription factor. If the "bait" and the "prey" proteins are able to interact *in vivo* to form an protein-dependent complex, the DNA-binding and activation domains of the transcription factor are brought into close proximity. This proximity allows transcription of a reporter gene (e.g., LacZ), which is operably linked to a transcriptional regulatory site responsive to the transcription factor. Expression of the reporter gene can be detected, and cell colonies containing the functional transcription factor can be isolated and used to obtain the DNA sequence encoding the protein which interacts with the histone deacetylase polypeptide.

It may be desirable to immobilize either the histone deacetylase polypeptide (or polynucleotide) or the test compound to facilitate separation of bound from unbound forms of one or both of the interactants, as well as to accommodate automation of the assay. Thus, either the histone deacetylase polypeptide (or polynucleotide) or the test compound can be bound to a solid support. Suitable solid supports include, but are not limited to, glass or plastic slides, tissue culture plates, microtiter wells, tubes, silicon chips, or particles such as beads (including, but not limited to, latex, polystyrene, or glass beads). Any method known in the art can be used to attach the enzyme polypeptide (or polynucleotide) or test compound to a solid support, including use of covalent and non-covalent linkages, passive absorption, or pairs of binding moieties attached respectively to the polypeptide (or polynucleotide) or test compound and the solid support. Test compounds are preferably bound to the solid support in an array, so that the location of individual test compounds can be tracked. Binding of a test compound to a histone deacetylase polypeptide (or polynucleotide) can be accomplished in any vessel suitable for containing the reactants. Examples of such vessels include microtiter plates, test tubes, and microcentrifuge tubes.

In one embodiment, the histone deacetylase polypeptide is a fusion protein comprising a domain that allows the histone deacetylase polypeptide to be bound to a solid support. For example, glutathione-S-transferase fusion proteins can be adsorbed onto glutathione sepharose beads (Sigma Chemical, St. Louis, Mo.) or glutathione derivatized microtiter plates, which are then combined with the test compound or the test compound and the non-adsorbed histone deacetylase polypeptide; the mixture is then incubated under conditions conducive to complex formation (*e.g.*, at physiological conditions for salt and pH). Following incubation, the beads or microtiter plate wells are washed to remove any unbound components. Binding of the interactants can be determined either directly or indirectly, as described above. Alternatively, the complexes can be dissociated from the solid support before binding is determined.

Other techniques for immobilizing proteins or polynucleotides on a solid support also can be used in the screening assays of the invention. For example, either a histone deacetylase polypeptide (or polynucleotide) or a test compound can be immobilized utilizing conjugation of biotin and streptavidin. Biotinylated histone deacetylase polypeptides (or polynucleotides) or test compounds can be prepared from biotin-NHS(N-hydroxysuccinimide) using techniques well known in the art (*e.g.*, biotinylation kit, Pierce Chemicals, Rockford, Ill.) and immobilized in the wells of streptavidin-coated 96 well plates (Pierce Chemical). Alternatively, antibodies which specifically bind to a histone deacetylase polypeptide, polynucleotide, or a test compound, but which do not interfere with a desired binding site, such as the active site of the histone deacetylase polypeptide, can be derivatized to the wells of the plate. Unbound target or protein can be trapped in the wells by antibody conjugation.

Methods for detecting such complexes, in addition to those described above for the GST-immobilized complexes, include immunodetection of complexes using antibodies which specifically bind to the histone deacetylase polypeptide or test compound, enzyme-linked assays which rely on detecting an activity of the histone deacetylase polypeptide, and SDS gel electrophoresis under non-reducing conditions.

Screening for test compounds which bind to a histone deacetylase polypeptide or polynucleotide also can be carried out in an intact cell. Any cell which comprises a histone deacetylase polypeptide or polynucleotide can be used in a cell-based assay system. A histone deacetylase polynucleotide can be naturally occurring in the cell or can be introduced using techniques such as those described above. Binding of the test compound to a histone deacetylase polypeptide or polynucleotide is determined as described above.

10 Enzyme Assays

Test compounds can be tested for the ability to increase or decrease the histone acetylase activity of a human histone deacetylase polypeptide. Histone acetylase activity can be measured, for example, as described in the specific examples, below.

15 Enzyme assays can be carried out after contacting either a purified histone deacetylase polypeptide, a cell membrane preparation, or an intact cell with a test compound. A test compound which decreases a histone acetylase activity of a histone deacetylase polypeptide by at least about 10, preferably about 50, more preferably about 75, 90, or 100% is identified as a potential therapeutic agent for decreasing histone deacetylase activity. A test compound which increases a histone acetylase activity of a human histone deacetylase polypeptide by at least about 10, preferably about 50, more preferably about 75, 90, or 100% is identified as a potential therapeutic agent for increasing human histone deacetylase activity.

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Gene Expression

In another embodiment, test compounds which increase or decrease histone deacetylase gene expression are identified. A histone deacetylase polynucleotide is contacted with a test compound, and the expression of an RNA or polypeptide product of the histone deacetylase polynucleotide is determined. The level of

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expression of appropriate mRNA or polypeptide in the presence of the test compound is compared to the level of expression of mRNA or polypeptide in the absence of the test compound. The test compound can then be identified as a modulator of expression based on this comparison. For example, when expression of mRNA or polypeptide is greater in the presence of the test compound than in its absence, the test compound is identified as a stimulator or enhancer of the mRNA or polypeptide expression. Alternatively, when expression of the mRNA or polypeptide is less in the presence of the test compound than in its absence, the test compound is identified as an inhibitor of the mRNA or polypeptide expression.

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The level of histone deacetylase mRNA or polypeptide expression in the cells can be determined by methods well known in the art for detecting mRNA or polypeptide. Either qualitative or quantitative methods can be used. The presence of polypeptide products of a histone deacetylase polynucleotide can be determined, for example, using a variety of techniques known in the art, including immunochemical methods such as radioimmunoassay, Western blotting, and immunohistochemistry. Alternatively, polypeptide synthesis can be determined *in vivo*, in a cell culture, or in an *in vitro* translation system by detecting incorporation of labeled amino acids into a histone deacetylase polypeptide.

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Such screening can be carried out either in a cell-free assay system or in an intact cell. Any cell which expresses a histone deacetylase polynucleotide can be used in a cell-based assay system. The histone deacetylase polynucleotide can be naturally occurring in the cell or can be introduced using techniques such as those described above. Either a primary culture or an established cell line, such as CHO or human embryonic kidney 293 cells, can be used.

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Pharmaceutical Compositions

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The invention also provides pharmaceutical compositions which can be administered to a patient to achieve a therapeutic effect. Pharmaceutical compositions of the

invention can comprise, for example, a histone deacetylase polypeptide, histone deacetylase polynucleotide, ribozymes or antisense oligonucleotides, antibodies which specifically bind to a histone deacetylase polypeptide, or mimetics, activators, inhibitors, or inhibitors of a histone deacetylase polypeptide activity. The compositions can be administered alone or in combination with at least one other agent, such as stabilizing compound, which can be administered in any sterile, biocompatible pharmaceutical carrier, including, but not limited to, saline, buffered saline, dextrose, and water. The compositions can be administered to a patient alone, or in combination with other agents, drugs or hormones.

In addition to the active ingredients, these pharmaceutical compositions can contain suitable pharmaceutically-acceptable carriers comprising excipients and auxiliaries which facilitate processing of the active compounds into preparations which can be used pharmaceutically. Pharmaceutical compositions of the invention can be administered by any number of routes including, but not limited to, oral, intravenous, intramuscular, intra-arterial, intramedullary, intrathecal, intraventricular, transdermal, subcutaneous, intraperitoneal, intranasal, parenteral, topical, sublingual, or rectal means. Pharmaceutical compositions for oral administration can be formulated using pharmaceutically acceptable carriers well known in the art in dosages suitable for oral administration. Such carriers enable the pharmaceutical compositions to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspensions, and the like, for ingestion by the patient.

Pharmaceutical preparations for oral use can be obtained through combination of active compounds with solid excipient, optionally grinding a resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired, to obtain tablets or dragee cores. Suitable excipients are carbohydrate or protein fillers, such as sugars, including lactose, sucrose, mannitol, or sorbitol; starch from corn, wheat, rice, potato, or other plants; cellulose, such as methyl cellulose, hydroxypropylmethyl-cellulose, or sodium carboxymethylcellulose; gums including arabic and tragacanth; and proteins such as gelatin and collagen. If desired,

disintegrating or solubilizing agents can be added, such as the cross-linked polyvinyl pyrrolidone, agar, alginic acid, or a salt thereof, such as sodium alginate.

5 Dragee cores can be used in conjunction with suitable coatings, such as concentrated sugar solutions, which also can contain gum arabic, talc, polyvinylpyrrolidone, carbopol gel, polyethylene glycol, and/or titanium dioxide, lacquer solutions, and suitable organic solvents or solvent mixtures. Dyestuffs or pigments can be added to the tablets or dragee coatings for product identification or to characterize the quantity of active compound, *i.e.*, dosage.

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Pharmaceutical preparations which can be used orally include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a coating, such as glycerol or sorbitol. Push-fit capsules can contain active ingredients mixed with a filler or binders, such as lactose or starches, lubricants, such as talc or magnesium stearate, and, optionally, stabilizers. In soft capsules, the active compounds can be dissolved or suspended in suitable liquids, such as fatty oils, liquid, or liquid polyethylene glycol with or without stabilizers.

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Pharmaceutical formulations suitable for parenteral administration can be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hanks' solution, Ringer's solution, or physiologically buffered saline. Aqueous injection suspensions can contain substances which increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, or dextran. Additionally, suspensions of the active compounds can be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl oleate or triglycerides, or liposomes. Non-lipid polycationic amino polymers also can be used for delivery. Optionally, the suspension also can contain suitable stabilizers or agents which increase the solubility of the compounds to allow for the preparation of highly concentrated solutions. For topical or nasal administration, penetrants appropriate to the particular

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barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

5 The pharmaceutical compositions of the present invention can be manufactured in a manner that is known in the art, e.g., by means of conventional mixing, dissolving, granulating, dragee-making, levigating, emulsifying, encapsulating, entrapping, or lyophilizing processes. The pharmaceutical composition can be provided as a salt and can be formed with many acids, including but not limited to, hydrochloric, sulfuric, acetic, lactic, tartaric, malic, succinic, etc. Salts tend to be more soluble in
10 aqueous or other protonic solvents than are the corresponding free base forms. In other cases, the preferred preparation can be a lyophilized powder which can contain any or all of the following: 1-50 mM histidine, 0.1%-2% sucrose, and 2-7% mannitol, at a pH range of 4.5 to 5.5, that is combined with buffer prior to use.

15 Further details on techniques for formulation and administration can be found in the latest edition of REMINGTON'S PHARMACEUTICAL SCIENCES (Maack Publishing Co., Easton, Pa.). After pharmaceutical compositions have been prepared, they can be placed in an appropriate container and labeled for treatment of an indicated condition. Such labeling would include amount, frequency, and method of admini-
20 stration.

Therapeutic Indications and Methods

Increasing evidence from recent research suggests a connection between cancer and a
25 deranged equilibrium of histone acetylation, which is maintained by two competing enzymatic activities, histone acetyltransferases (HATs) and histone deacetylases (HDACs). Zwiebel, *Leukemia* 14, 488-90, 2000; Melhick *et al.*, *Mol. Cell. Biol.* 20, 2075-86, 2000; Kosugi *et al.*, *Leukemia* 13, 1316-24, 1999; Wang *et al.*, *Cancer Res.* 59, 2766-69, 1999; Fenrick & Hiebert, *J. Cell. Biochem. Suppl.* 30-31, 194-202,
30 1998; Wang *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 95, 10860-65, 1998.

A significant proportion of leukemias and possibly also solid tumors may have abnormalities involving HATs or HDACs at the genomic level through genetic mutations or chromosomal alterations. In these cases, altered levels of HATs or HDACs may derange the tightly regulated equilibrium of histone acetylation, which
5 may affect the expression of a broad spectrum of cellular genes. On the other hand, HATs and HDACs may be carried to defined target promoters as cofactors of transcription factor-bound repressor or enhancer complexes and thereby carry out unwanted enzymatic activities in the wrong place at the wrong time. We therefore propose a model for disease being associated with a deranged equilibrium of
10 acetylation that affects histone proteins and promoter-bound transcription factors.

Human histone deacetylase, therefore, can be regulated to treat cancer. Cancer is a disease fundamentally caused by oncogenic cellular transformation. There are several hallmarks of transformed cells that distinguish them from their normal
15 counterparts and underlie the pathophysiology of cancer. These include uncontrolled cellular proliferation, unresponsiveness to normal death-inducing signals (immortalization), increased cellular motility and invasiveness, increased ability to recruit blood supply through induction of new blood vessel formation (angiogenesis), genetic instability, and dysregulated gene expression. Various combinations of these
20 aberrant physiologies, along with the acquisition of drug-resistance frequently lead to an intractable disease state in which organ failure and patient death ultimately ensue.

Most standard cancer therapies target cellular proliferation and rely on the differential proliferative capacities between transformed and normal cells for their
25 efficacy. This approach is hindered by the facts that several important normal cell types are also highly proliferative and that cancer cells frequently become resistant to these agents. Thus, the therapeutic indices for traditional anti-cancer therapies rarely exceed 2.0.

30 The advent of genomics-driven molecular target identification has opened up the possibility of identifying new cancer-specific targets for therapeutic intervention that

will provide safer, more effective treatments for cancer patients. Thus, newly discovered tumor-associated genes and their products can be tested for their role(s) in disease and used as tools to discover and develop innovative therapies. Genes playing important roles in any of the physiological processes outlined above can be characterized as cancer targets.

Genes or gene fragments identified through genomics can readily be expressed in one or more heterologous expression systems to produce functional recombinant proteins. These proteins are characterized *in vitro* for their biochemical properties and then used as tools in high-throughput molecular screening programs to identify chemical modulators of their biochemical activities. Activators and/or inhibitors of target protein activity can be identified in this manner and subsequently tested in cellular and *in vivo* disease models for anti-cancer activity. Optimization of lead compounds with iterative testing in biological models and detailed pharmacokinetic and toxicological analyses form the basis for drug development and subsequent testing in humans.

This invention further pertains to the use of novel agents identified by the screening assays described above. Accordingly, it is within the scope of this invention to use a test compound identified as described herein in an appropriate animal model. For example, an agent identified as described herein (*e.g.*, a modulating agent, an antisense nucleic acid molecule, a specific antibody, ribozyme, or a histone deacetylase polypeptide binding molecule) can be used in an animal model to determine the efficacy, toxicity, or side effects of treatment with such an agent. Alternatively, an agent identified as described herein can be used in an animal model to determine the mechanism of action of such an agent. Furthermore, this invention pertains to uses of novel agents identified by the above-described screening assays for treatments as described herein.

A reagent which affects histone deacetylase activity can be administered to a human cell, either *in vitro* or *in vivo*, to reduce histone deacetylase activity. The reagent

preferably binds to an expression product of a human histone deacetylase gene. If the expression product is a protein, the reagent is preferably an antibody. For treatment of human cells *ex vivo*, an antibody can be added to a preparation of stem cells which have been removed from the body. The cells can then be replaced in the
5 same or another human body, with or without clonal propagation, as is known in the art.

In one embodiment, the reagent is delivered using a liposome. Preferably, the liposome is stable in the animal into which it has been administered for at least about
10 30 minutes, more preferably for at least about 1 hour, and even more preferably for at least about 24 hours. A liposome comprises a lipid composition that is capable of targeting a reagent, particularly a polynucleotide, to a particular site in an animal, such as a human. Preferably, the lipid composition of the liposome is capable of targeting to a specific organ of an animal, such as the lung, liver, spleen, heart brain,
15 lymph nodes, and skin.

A liposome useful in the present invention comprises a lipid composition that is capable of fusing with the plasma membrane of the targeted cell to deliver its contents to the cell. Preferably, the transfection efficiency of a liposome is about
20 0.5 μg of DNA per 16 nmole of liposome delivered to about 10^6 cells, more preferably about 1.0 μg of DNA per 16 nmole of liposome delivered to about 10^6 cells, and even more preferably about 2.0 μg of DNA per 16 nmol of liposome delivered to about 10^6 cells. Preferably, a liposome is between about 100 and 500 nm, more preferably between about 150 and 450 nm, and even more preferably
25 between about 200 and 400 nm in diameter.

Suitable liposomes for use in the present invention include those liposomes standardly used in, for example, gene delivery methods known to those of skill in the art. More preferred liposomes include liposomes having a polycationic lipid
30 composition and/or liposomes having a cholesterol backbone conjugated to polyethylene glycol. Optionally, a liposome comprises a compound capable of

targeting the liposome to a particular cell type, such as a cell-specific ligand exposed on the outer surface of the liposome.

5 Complexing a liposome with a reagent such as an antisense oligonucleotide or ribozyme can be achieved using methods which are standard in the art (see, for example, U.S. Patent 5,705,151). Preferably, from about 0.1 μ g to about 10 μ g of polynucleotide is combined with about 8 nmol of liposomes, more preferably from about 0.5 μ g to about 5 μ g of polynucleotides are combined with about 8 nmol liposomes, and even more preferably about 1.0 μ g of polynucleotides is combined
10 with about 8 nmol liposomes.

In another embodiment, antibodies can be delivered to specific tissues *in vivo* using receptor-mediated targeted delivery. Receptor-mediated DNA delivery techniques are taught in, for example, Findeis *et al.* *Trends in Biotechnol.* 11, 202-05 (1993);
15 Chiou *et al.*, GENE THERAPEUTICS: METHODS AND APPLICATIONS OF DIRECT GENE TRANSFER (J.A. Wolff, ed.) (1994); Wu & Wu, *J. Biol. Chem.* 263, 621-24 (1988); Wu *et al.*, *J. Biol. Chem.* 269, 542-46 (1994); Zenke *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 87, 3655-59 (1990); Wu *et al.*, *J. Biol. Chem.* 266, 338-42 (1991).

20 Determination of a Therapeutically Effective Dose

The determination of a therapeutically effective dose is well within the capability of those skilled in the art. A therapeutically effective dose refers to that amount of active ingredient which increases or decreases histone deacetylase activity relative to
25 the histone deacetylase activity which occurs in the absence of the therapeutically effective dose.

For any compound, the therapeutically effective dose can be estimated initially either in cell culture assays or in animal models, usually mice, rabbits, dogs, or pigs. The
30 animal model also can be used to determine the appropriate concentration range and

route of administration. Such information can then be used to determine useful doses and routes for administration in humans.

5 Therapeutic efficacy and toxicity, *e.g.*, ED₅₀ (the dose therapeutically effective in 50% of the population) and LD₅₀ (the dose lethal to 50% of the population), can be determined by standard pharmaceutical procedures in cell cultures or experimental animals. The dose ratio of toxic to therapeutic effects is the therapeutic index, and it can be expressed as the ratio, LD₅₀/ED₅₀.

10 Pharmaceutical compositions which exhibit large therapeutic indices are preferred. The data obtained from cell culture assays and animal studies is used in formulating a range of dosage for human use. The dosage contained in such compositions is preferably within a range of circulating concentrations that include the ED₅₀ with little or no toxicity. The dosage varies within this range depending upon the dosage
15 form employed, sensitivity of the patient, and the route of administration.

The exact dosage will be determined by the practitioner, in light of factors related to the subject that requires treatment. Dosage and administration are adjusted to provide sufficient levels of the active ingredient or to maintain the desired effect.
20 Factors which can be taken into account include the severity of the disease state, general health of the subject, age, weight, and gender of the subject, diet, time and frequency of administration, drug combination(s), reaction sensitivities, and tolerance/response to therapy. Long-acting pharmaceutical compositions can be administered every 3 to 4 days, every week, or once every two weeks depending on
25 the half-life and clearance rate of the particular formulation.

Normal dosage amounts can vary from 0.1 to 100,000 micrograms, up to a total dose of about 1 g, depending upon the route of administration. Guidance as to particular dosages and methods of delivery is provided in the literature and generally available
30 to practitioners in the art. Those skilled in the art will employ different formulations for nucleotides than for proteins or their inhibitors. Similarly, delivery of poly-

nucleotides or polypeptides will be specific to particular cells, conditions, locations, etc.

5 If the reagent is a single-chain antibody, polynucleotides encoding the antibody can be constructed and introduced into a cell either *ex vivo* or *in vivo* using well-established techniques including, but not limited to, transferrin-polycation-mediated DNA transfer, transfection with naked or encapsulated nucleic acids, liposome-mediated cellular fusion, intracellular transportation of DNA-coated latex beads, protoplast fusion, viral infection, electroporation, "gene gun," and DEAE- or calcium
10 phosphate-mediated transfection.

Effective *in vivo* dosages of an antibody are in the range of about 5 μ g to about 50 μ g/kg, about 50 μ g to about 5 mg/kg, about 100 μ g to about 500 μ g/kg of patient body weight, and about 200 to about 250 μ g/kg of patient body weight. For
15 administration of polynucleotides encoding single-chain antibodies, effective *in vivo* dosages are in the range of about 100 ng to about 200 ng, 500 ng to about 50 mg, about 1 μ g to about 2 mg, about 5 μ g to about 500 μ g, and about 20 μ g to about 100 μ g of DNA.

20 If the expression product is mRNA, the reagent is preferably an antisense oligonucleotide or a ribozyme. Polynucleotides which express antisense oligonucleotides or ribozymes can be introduced into cells by a variety of methods, as described above.

25 Preferably, a reagent reduces expression of a histone deacetylase gene or the activity of a histone deacetylase polypeptide by at least about 10, preferably about 50, more preferably about 75, 90, or 100% relative to the absence of the reagent. The effectiveness of the mechanism chosen to decrease the level of expression of a histone deacetylase gene or the activity of a histone deacetylase polypeptide can be
30 assessed using methods well known in the art, such as hybridization of nucleotide probes to histone deacetylase-specific mRNA, quantitative RT-PCR, immunologic

detection of a histone deacetylase polypeptide, or measurement of histone deacetylase activity.

5 In any of the embodiments described above, any of the pharmaceutical compositions of the invention can be administered in combination with other appropriate therapeutic agents. Selection of the appropriate agents for use in combination therapy can be made by one of ordinary skill in the art, according to conventional pharmaceutical principles. The combination of therapeutic agents can act synergistically to effect the treatment or prevention of the various disorders described above. Using this approach, one may be able to achieve therapeutic efficacy with lower dosages of each agent, thus reducing the potential for adverse side effects.

15 Any of the therapeutic methods described above can be applied to any subject in need of such therapy, including, for example, mammals such as dogs, cats, cows, horses, rabbits, monkeys, and most preferably, humans.

Diagnostic Methods

20 Human histone deacetylase also can be used in diagnostic assays for detecting diseases and abnormalities or susceptibility to diseases and abnormalities related to the presence of mutations in the nucleic acid sequences which encode the enzyme. For example, differences can be determined between the cDNA or genomic sequence encoding histone deacetylase in individuals afflicted with a disease and in normal individuals. If a mutation is observed in some or all of the afflicted individuals but not in normal individuals, then the mutation is likely to be the causative agent of the disease.

30 Sequence differences between a reference gene and a gene having mutations can be revealed by the direct DNA sequencing method. In addition, cloned DNA segments can be employed as probes to detect specific DNA segments. The sensitivity of this method is greatly enhanced when combined with PCR. For example, a sequencing

primer can be used with a double-stranded PCR product or a single-stranded template molecule generated by a modified PCR. The sequence determination is performed by conventional procedures using radiolabeled nucleotides or by automatic sequencing procedures using fluorescent tags.

5

Genetic testing based on DNA sequence differences can be carried out by detection of alteration in electrophoretic mobility of DNA fragments in gels with or without denaturing agents. Small sequence deletions and insertions can be visualized, for example, by high resolution gel electrophoresis. DNA fragments of different sequences can be distinguished on denaturing formamide gradient gels in which the mobilities of different DNA fragments are retarded in the gel at different positions according to their specific melting or partial melting temperatures (*see, e.g., Myers et al., Science 230, 1242, 1985*). Sequence changes at specific locations can also be revealed by nuclease protection assays, such as RNase and S 1 protection or the chemical cleavage method (*e.g., Cotton et al., Proc. Natl. Acad. Sci. USA 85, 4397-4401, 1985*). Thus, the detection of a specific DNA sequence can be performed by methods such as hybridization, RNase protection, chemical cleavage, direct DNA sequencing or the use of restriction enzymes and Southern blotting of genomic DNA. In addition to direct methods such as gel-electrophoresis and DNA sequencing, mutations can also be detected by *in situ* analysis.

15
20

Altered levels of a histone deacetylase also can be detected in various tissues. Assays used to detect levels of the receptor polypeptides in a body sample, such as blood or a tissue biopsy, derived from a host are well known to those of skill in the art and include radioimmunoassays, competitive binding assays, Western blot analysis, and ELISA assays.

25

All patents and patent applications cited in this disclosure are expressly incorporated herein by reference. The above disclosure generally describes the present invention. A more complete understanding can be obtained by reference to the following

30

specific examples which are provided for purposes of illustration only and are not intended to limit the scope of the invention.

EXAMPLE 1

5

Detection of histone deacetylase activity

The polynucleotide of SEQ ID NO: 1 is inserted into the expression vector pCEV4 and the expression vector pCEV4-histone deacetylase polypeptide obtained is transfected into human embryonic kidney 293 cells. From these cells extracts are obtained and histone deacetylase activity is measured in an assay in a total volume of 40 μ l : 400 nmol HEPES-sodium, pH 7.4, 100 pmol of the substrate [AcGly-Ala-Lys(- 14 C-Ac)-Arg-His-Arg-Lys(14 C-Ac)-ValNH₂] (see Kervabon *et al.*, *FEBS Letters* 106, 93-96, 1979) having a specific activity of approximately 114 mCi/mmol, and the cell extract as deacetylase activity source. The amount of the cell extract is chosen such that about 20% of the substrate is consumed during the assay. The reaction is initiated by cell extract addition and allowed to proceed for 60 min at 41 degrees. At 60 min, the reaction is terminated by the addition of a 50% slurry of Amberlite.RTM. AG 50 W x 4 cation exchange resin, sodium form (200-400 mesh) in 25 mM sodium acetate buffer, pH 4.2 (200 μ l). The resin binds both remaining substrate and the (partially) deacetylated peptidyl products. The quenched reaction is then incubated for at least 30 min at 25° with occasional mixing, diluted with additional 25 mM sodium acetate buffer, pH.4.2 (760 μ ; final volume 1000 μ), incubated for a minimum of an additional 30 min at 25 degrees with occasional mixing, and then centrifuged at 10,000 x g for 1 min. An aliquot of the supernatant (800 μ l) containing the enzymatically released 14 C-acetate is removed, mixed with Aquasol 2 liquid scintillation counter (LSC) cocktail (10 ml), and counted in a Beckman model LS-5801 LSC. To assure that the acetate released is due specifically to the action of histone deacetylase, a parallel control incubation is performed which contained a known histone deacetylase inhibitor [originally, 1-5 mM butyrate (see Cousens *et al* (1979) *J. Biol. Chem.* 254: 1716-1723); later, 40-1000 nM apicidin in

DMSO once it had been demonstrated to be an histone deacetylase inhibitor]; the amount of radioactivity generated in the presence of inhibitor is subtracted from the value obtained in the absence of inhibitor in order to calculate histone deacetylase dependent acetate production. It is shown that the polypeptide of SEQ ID NO: 2 has a histone deacetylase activity.

EXAMPLE 2

Expression of recombinant human histone deacetylase

10

The *Pichia pastoris* expression vector pPICZB (Invitrogen, San Diego, CA) is used to produce large quantities of recombinant human histone deacetylase polypeptides in yeast. The histone deacetylase-encoding DNA sequence is derived from SEQ ID NO: 1. Before insertion into vector pPICZB, the DNA sequence is modified by well known methods in such a way that it contains at its 5'-end an initiation codon and at its 3'-end an enterokinase cleavage site, a His6 reporter tag and a termination codon. Moreover, at both termini recognition sequences for restriction endonucleases are added and after digestion of the multiple cloning site of pPICZ B with the corresponding restriction enzymes the modified DNA sequence is ligated into pPICZB. This expression vector is designed for inducible expression in *Pichia pastoris*, driven by a yeast promoter. The resulting pPICZ/md-His6 vector is used to transform the yeast.

20

The yeast is cultivated under usual conditions in 5 liter shake flasks and the recombinantly produced protein isolated from the culture by affinity chromatography (Ni-NTA-Resin) in the presence of 8 M urea. The bound polypeptide is eluted with buffer, pH 3.5, and neutralized. Separation of the polypeptide from the His6 reporter tag is accomplished by site-specific proteolysis using enterokinase (Invitrogen, San Diego, CA) according to manufacturer's instructions. Purified human histone deacetylase polypeptide is obtained.

25

30

EXAMPLE 3*Identification of test compounds that bind to histone deacetylase polypeptides*

5 Purified histone deacetylase polypeptides comprising a glutathione-S-transferase protein and absorbed onto glutathione-derivatized wells of 96-well microtiter plates are contacted with test compounds from a small molecule library at pH 7.0 in a physiological buffer solution. Human histone deacetylase polypeptides comprise the amino acid sequence shown in SEQ ID NO: 2. The test compounds comprise a
10 fluorescent tag. The samples are incubated for 5 minutes to one hour. Control samples are incubated in the absence of a test compound.

The buffer solution containing the test compounds is washed from the wells. Binding of a test compound to a histone deacetylase polypeptide is detected by
15 fluorescence measurements of the contents of the wells. A test compound which increases the fluorescence in a well by at least 15% relative to fluorescence of a well in which a test compound is not incubated is identified as a compound which binds to a histone deacetylase polypeptide.

EXAMPLE 4*Identification of a test compound which decreases histone deacetylase gene expression*

25 A test compound is administered to a culture of human cells transfected with a histone deacetylase expression construct and incubated at 37°C for 10 to 45 minutes. A culture of the same type of cells which have not been transfected is incubated for the same time without the test compound to provide a negative control.

30 RNA is isolated from the two cultures as described in Chirgwin *et al.*, *Biochem.* 18, 5294-99, 1979). Northern blots are prepared using 20 to 30 µg total RNA and

hybridized with a ^{32}P -labeled histone deacetylase-specific probe at 65°C in Express-hyb (CLONTECH). The probe comprises at least 11 contiguous nucleotides selected from the complement of SEQ ID NO: 1. A test compound which decreases the histone deacetylase-specific signal relative to the signal obtained in the absence of the test compound is identified as an inhibitor of histone deacetylase gene expression.

EXAMPLE 5

10 *Identification of a test compound which decreases histone deacetylase activity*

A test compound is administered to a culture of human cells transfected with a histone deacetylase expression construct and incubated at 37°C for 10 to 45 minutes. A culture of the same type of cells which have not been transfected is incubated for the same time without the test compound to provide a negative control. Histone deacetylase activity is measured using the methods described in Example 5.

A test compound which decreases the histone acetylase activity of the histone deacetylase relative to the histone acetylase activity in the absence of the test compound is identified as an inhibitor of histone deacetylase activity.

EXAMPLE 6

Histone Deacetylase Assays (all temperatures in $^\circ\text{C}$):

25

Assay 1 for Histone Deacetylase Activity and Inhibition. The standard assay is contained in a total volume of $40\ \mu\text{l}$: 400 nmol HEPES-sodium, pH 7.4, 100 pmol of the substrate $[\text{AcGly-Ala-Lys}(^{14}\text{C-Ac})\text{-Arg-His-Arg-Lys}(^{14}\text{C-Ac})\text{-ValNH}_2]$ (see Kervabon *et al.*, *FEBS Letters* 106, 93-96, 1979) having a specific activity of approximately 114 mCi/mmol, and a source of histone deacetylase (HDAase) activity. The amount of HDAase added is chosen such that about 20% of the

substrate is consumed during the assay. The reaction is initiated by enzyme addition and allowed to proceed for 60 min at 41 degrees. At 60 min, the reaction is terminated by the addition of a 50% slurry of Amberlite.RTM. AG 50 W x 4 cation exchange resin, sodium form (200-400 mesh) in 25 mM sodium acetate buffer, pH 4.2 (200 μ l). The resin binds both remaining substrate and the (partially) deacetylated peptidyl products. The quenched reaction is then incubated for at least 30 min at 25° with occasional mixing, diluted with additional 25 mM sodium acetate buffer, pH 4.2 (760 μ l; final volume 1000 μ l), incubated for a minimum of an additional 30 min at 25 degrees with occasional mixing, and then centrifuged at 10,000 x g for 1 min. An aliquot of the supernatant (800 μ l) containing the enzymatically released 14 C-acetate is removed, mixed with Aquasol 2 liquid scintillation counter (LSC) cocktail (10 ml), and counted in a Beckman model LS-5801 LSC. To assure that the acetate released is due specifically to the action of HDAase, a parallel control incubation is performed which contained a known HDAase inhibitor [originally, 1-5 mM butyrate (see Cousens et al (1979) J. Biol. Chem. 254: 1716-1723); later, 40-1000 nM apicidin in DMSO once it had been demonstrated to be an HDAase inhibitor]; the amount of radioactivity generated in the presence of inhibitor is subtracted from the value obtained in the absence of inhibitor in order to calculate HDAase dependent acetate production.

20

For inhibition studies, the inhibitor under examination is added to the standard assay cocktail at the desired concentration in dimethyl sulfoxide (final concentration of DMSO in the reaction is kept constant at 2.5% v/v) and the HDAase activity compared to that found in control (minus inhibitor) incubations which lacked inhibitor but contained 2.5% v/v final DMSO.

25

Assay 2 for Histone Deacetylase Activity and Inhibition. The standard assay is contained in a total volume of 200 μ l: 2000 nmol HEPES-sodium, pH 7.4, 11 pmol AcGly-Ala-Lys(3 H-Ac)-Arg-His-Arg-Lys(3 H-Ac)-ValNH₂ having a specific activity of approximately 3 Ci/mmol, and a source of histone deacetylase (HDAase) activity. The amount of HDAase added is chosen such that approximately 20% of the

30

substrate is consumed during the assay. The reaction is initiated by enzyme addition and allowed to proceed for 60 min at 41 degrees. At 60 min, the reaction is terminated by the addition of a aqueous solution containing 0.1 M acetic acid and 0.5 M hydrochloric acid (20 μ l), followed by the addition of ethyl acetate (1000 μ l).
5 The quenched reaction is then vortexed for at least 15 sec at 25 degrees and then centrifuged at 10,000 X g for 1 min. An aliquot of the ethyl acetate phase (900 μ l) containing the enzymatically released 3 H-acetate is removed, mixed with Aquasol 2 liquid scintillation counter (LSC) cocktail (6 ml), and counted in a Beckman model LS-5801 LSC. To assure that the acetate released is due specifically to the action of
10 HDAase, a parallel control incubation is performed which contained a known HDAase inhibitor [originally, 1-5 mM butyrate; later, 40-1000 nM apicidin in DMSO once it had been demonstrated to be an HDAase inhibitor]; the amount of radioactivity generated in the presence of inhibitor is subtracted from the value obtained in the absence of inhibitor in order to calculate HDAase dependent acetate
15 production.

For inhibition studies, the inhibitor under examination is added to the standard assay cocktail at the desired concentration in dimethyl sulfoxide (final concentration of DMSO in the reaction is kept constant at 0.5% v/v) and the HDAase activity
20 compared to that found in control (minus inhibitor) incubations which lacked inhibitor but contained 0.5% v/v final DMSO.

EXAMPLE 7

25 *PCR analysis using cDNAs from human tissues*

0.5 μ l of each cDNA sample is used as template in PCR for semi quantitative expression analysis. PCR is performed according to standard protocols. In addition a positive control PCR reaction is performed with about 20 ng of human genomic
30 DNA as template and a negative control is performed with no template.
The results are shown in Fig. 26.

Quantitative analysis of relative expression of *Histone Deacetylase* in human tissues

Quantitative expression profiling is performed by the form of quantitative PCR analysis called "kinetic analysis" firstly described in Higuchi et al., 1992 and Higuchi

5 et al., 1993. The principle is that at any given cycle within the exponential phase of PCR, the amount of product is proportional to the initial number of template copies.

If the amplification is performed in the presence of an internally quenched fluorescent oligonucleotide (TaqMan probe) complementary to the target sequence,

10 the probe is cleaved by the 5'-3' endonuclease activity of Taq DNA polymerase and a fluorescent dye released in the medium (Holland et al.). Since the fluorescence emission will increase in direct proportion to the amount of the specific amplified product, the exponential growth phase of PCR product can be detected and used to determine the initial template concentration (Heid et al., 1996, and Gibson et al., 1996).

15

The amplification of an endogenous control can be performed to standardise the amount of sample RNA added to a reaction. In this kind of experiments the control of choice is the 18S ribosomal RNA. Since reporter dyes with differing emission spectra are available, the target and the endogenous control can be independently

20 quantified in the same tube if probes labelled with different dyes are used.

All "real time PCR" measurements of fluorescence are made in the ABI Prism 7700 Sequence detector System (PE Applied Biosystems, Foster City, CA).

25

References

- Higuchi, R., Dollinger, G., Walsh, P.S. and Griffith, R. 1992. Simultaneous amplification and detection of specific DNA sequences. *BioTechnology* 10:413-417.

30

- Higuchi, R., Fockler, C., Dollinger, G. and Watson, R. 1993. Kinetic PCR analysis: real-time monitoring of DNA amplification reactions. *BioTechnology* 11:1026-1030.
- 5 • Holland, P.M., Abramson, R.D., Watson, R. and Gelfand, D.H. 1991. Detection of specific polymerase chain reaction product by utilizing the 5'-3' exonuclease activity of *Thermus aquaticus* DNA polymerase. *Proc.Natl.Acad.Sci.* 88:7276-7280.
- 10 • Heid, C., Stevens, J., Livak, K. And Williams, P.M. 1996. Real time quantitative PCR. *Genome Res.* 6:986-994.
- Gibson, U.E., Heid, C.A. and Williams, P.M. 1996. A novel method for real time quantitative RT-PCR. *Genome Res.* 6: 995-1001.

15

cDNA preparation

Fifty µgs of each RNA are treated with DNase I for 1 hour at 37°C in the following reaction mix:

20

DNase I, RNase-free (Roche Diagnostics, Germany)	0.2 U/µL
Rnase inhibitor (PE Applied Biosystems, CA)	0.4 U/µL
Tris-HCl pH 7.9	10mM
MgCl ₂	10mM
25 NaCl	50mM
DTT	1mM

30

After incubation, RNA is extracted once with 1 volume of phenol:chloroform:-isoamyl alcohol (24:24:1) and once with chloroform, and precipitated with 1/10 volume of NaAcetate 3M pH5.2 and 2 volumes ethanol.

After spectrophotometric quantification, each sample is reverse transcribed with the TaqMan Reverse Transcription Reagents (PE Applied Biosystems, CA) accordingly to purchaser protocol. RNA final concentration in the reaction mix is 200 ng/ μ L.

5 Reverse transcription is made with 2.5 μ M of random hexamers.

TaqMan quantitative analysis

Gene specific primers and probe are designed accordingly to PE Applied Biosystems
10 recommendations.

Total cDNA content is normalized with the simultaneous quantification (multiplex PCR) of the 18S ribosomal RNA by use of the Pre-Developed TaqMan Assay Reagents (PDAR) Control Kit (PE Applied Biosystems, CA).

15

Assay reaction mix is as follows:

	final	
	TaqMan Universal PCR Master Mix (2x)	1x
	(PE Applied Biosystems, CA)	
20	PDAR control – 18S RNA (20x)	1x
	Forward primer	300nM
	Reverse primer	900nM
	Probe	200nM
	cDNA	10ng
25	Water	to 25 μ L

PCR conditions are:

1 time the following steps:

pre PCR 2' at 50° C

30 10' at 95°C

40 times the following steps:

- 64 -

denaturation 15'' at 95°C

annealing/extension 1' at 60°C

5 The experiment is performed on an ABI Prism 7700 Sequence Detector (PE Applied Biosystems, CA). At the end of the run, fluorescence data acquired during PCR are processed as described in the ABI Prism 7700 user's manual in order to achieve better background subtraction as well as signal linearity with the starting target quantity.

10 The results are shown in Figs. 27 and 28.

CLAIMS

1. An isolated polynucleotide encoding a histone deacetylase polypeptide and being selected from the group consisting of:
- 5
- a) a polynucleotide encoding a histone deacetylase polypeptide comprising an amino acid sequence selected from the group consisting of:
- 10 amino acid sequences which are at least about 52% identical to the amino acid sequence shown in SEQ ID NO: 2; and the amino acid sequence shown in SEQ ID NO: 2;
- b) a polynucleotide comprising the sequence of SEQ ID NO: 1;
- 15 c) a polynucleotide which hybridizes under stringent conditions to a polynucleotide specified in (a) and (b);
- d) a polynucleotide the sequence of which deviates from the polynucleotide sequences specified in (a) to (c) due to the degeneration of the genetic code; and
- 20 e) a polynucleotide which represents a fragment, derivative or allelic variation of a polynucleotide sequence specified in (a) to (d).
- 25 2. An expression vector containing any polynucleotide of claim 1.
3. A host cell containing the expression vector of claim 2.
4. A substantially purified histone deacetylase polypeptide encoded by a polynucleotide of claim 1.
- 30

5. A method for producing a histone deacetylase polypeptide, wherein the method comprises the following steps:
- a) culturing the host cell of claim 3 under conditions suitable for the expression of the histone deacetylase polypeptide; and
 - b) recovering the histone deacetylase polypeptide from the host cell culture.
6. A method for detection of a polynucleotide encoding a histone deacetylase polypeptide in a biological sample comprising the following steps:
- a) hybridizing any polynucleotide of claim 1 to a nucleic acid material of a biological sample, thereby forming a hybridization complex; and
 - b) detecting said hybridization complex.
7. The method of claim 6, wherein before hybridization, the nucleic acid material of the biological sample is amplified.
8. A method for the detection of a polynucleotide of claim 1 or a histone deacetylase polypeptide of claim 4 comprising the steps of:
- contacting a biological sample with a reagent which specifically interacts with the polynucleotide or the histone deacetylase polypeptide.
9. A diagnostic kit for conducting the method of any one of claims 6 to 8.
10. A method of screening for agents which decrease the activity of a histone deacetylase, comprising the steps of:

contacting a test compound with any histone deacetylase polypeptide encoded by any polynucleotide of claim 1;

5 detecting binding of the test compound to the histone deacetylase polypeptide, wherein a test compound which binds to the polypeptide is identified as a potential therapeutic agent for decreasing the activity of a histone deacetylase.

11. 10 A method of screening for agents which regulate the activity of a histone deacetylase, comprising the steps of:

contacting a test compound with a histone deacetylase polypeptide encoded by any polynucleotide of claim 1; and

15 detecting a histone deacetylase activity of the polypeptide, wherein a test compound which increases the histone deacetylase activity is identified as a potential therapeutic agent for increasing the activity of the histone deacetylase, and wherein a test compound which decreases the histone deacetylase activity of the polypeptide is identified as a potential therapeutic agent for decreasing the activity of the histone deacetylase.

12. A method of screening for agents which decrease the activity of a histone deacetylase, comprising the steps of:

25 contacting a test compound with any polynucleotide of claim 1 and detecting binding of the test compound to the polynucleotide, wherein a test compound which binds to the polynucleotide is identified as a potential therapeutic agent for decreasing the activity of histone deacetylase.

30 13. A method of reducing the activity of histone deacetylase, comprising the steps of:

contacting a cell with a reagent which specifically binds to any polynucleotide of claim 1 or any histone deacetylase polypeptide of claim 4, whereby the activity of histone deacetylase is reduced.

- 5 14. A reagent that modulates the activity of a histone deacetylase polypeptide or a polynucleotide wherein said reagent is identified by the method of any of the claim 10 to 12.
- 10 15. A pharmaceutical composition, comprising:
the expression vector of claim 2 or the reagent of claim 14 and a pharmaceutically acceptable carrier.
- 15 16. Use of the expression vector of claim 2 or the reagent of claim 14 for the preparation of a medicament for modulating the activity of a histone deacetylase in a disease.
17. Use of claim 16 wherein the disease is cancer.
- 20 18. A cDNA encoding a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2.
19. The cDNA of claim 18 which comprises SEQ ID NO: 1.
20. The cDNA of claim 18 which consists of SEQ ID NO: 1.
- 25 21. An expression vector comprising a polynucleotide which encodes a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2.
- 30 22. The expression vector of claim 21 wherein the polynucleotide consists of SEQ ID NO: 1.

23. A host cell comprising an expression vector which encodes a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2.
24. The host cell of claim 23 wherein the polynucleotide consists of SEQ ID NO:
5 1.
25. A purified polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2.
- 10 26. The purified polypeptide of claim 25 which consists of the amino acid sequence shown in SEQ ID NO: 2.
27. A fusion protein comprising a polypeptide having the amino acid sequence shown in SEQ ID NO: 2.
- 15 28. A method of producing a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2, comprising the steps of:
- 20 culturing a host cell comprising an expression vector which encodes the polypeptide under conditions whereby the polypeptide is expressed; and
- isolating the polypeptide.
29. The method of claim 28 wherein the expression vector comprises SEQ ID
25 NO: 1.
30. A method of detecting a coding sequence for a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2, comprising the steps of:

hybridizing a polynucleotide comprising 11 contiguous nucleotides of SEQ. ID NO: 1 to nucleic acid material of a biological sample, thereby forming a hybridization complex; and

5 detecting the hybridization complex.

31. The method of claim 30 further comprising the step of amplifying the nucleic acid material before the step of hybridizing.

10 32. A kit for detecting a coding sequence for a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2, comprising:

a polynucleotide comprising 11 contiguous nucleotides of SEQ ID NO: 1; and

15 instructions for the method of claim 30.

33. A method of detecting a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2, comprising the steps of:

20 contacting a biological sample with a reagent that specifically binds to the polypeptide to form a reagent-polypeptide complex; and

detecting the reagent-polypeptide complex.

25 34. The method of claim 33 wherein the reagent is an antibody.

35. A kit for detecting a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2, comprising:

30 an antibody which specifically binds to the polypeptide; and

instructions for the method of claim 33.

36. A method of screening for agents which can modulate the activity of a human histone deacetylase, comprising the steps of:

5

contacting a test compound with a polypeptide comprising an amino acid sequence selected from the group consisting of: (1) amino acid sequences which are at least about 52% identical to the amino acid sequence shown in SEQ ID NO: 2 and (2) the amino acid sequence shown in SEQ ID NO: 2; and

10

detecting binding of the test compound to the polypeptide, wherein a test compound which binds to the polypeptide is identified as a potential agent for regulating activity of the human histone deacetylase.

15

37. The method of claim 36 wherein the step of contacting is in a cell.

38. The method of claim 36 wherein the cell is *in vitro*.

20

39. The method of claim 36 wherein the step of contacting is in a cell-free system.

40. The method of claim 36 wherein the polypeptide comprises a detectable label.

25

41. The method of claim 36 wherein the test compound comprises a detectable label.

42. The method of claim 36 wherein the test compound displaces a labeled ligand which is bound to the polypeptide.

30

43. The method of claim 36 wherein the polypeptide is bound to a solid support.

44. The method of claim 36 wherein the test compound is bound to a solid support.

45. A method of screening for agents which modulate an activity of a human histone deacetylase, comprising the steps of:

contacting a test compound with a polypeptide comprising an amino acid sequence selected from the group consisting of: (1) amino acid sequences which are at least about 52% identical to the amino acid sequence shown in SEQ ID NO: 2 and (2) the amino acid sequence shown in SEQ ID NO: 2; and

detecting an activity of the polypeptide, wherein a test compound which increases the activity of the polypeptide is identified as a potential agent for increasing the activity of the human histone deacetylase, and wherein a test compound which decreases the activity of the polypeptide is identified as a potential agent for decreasing the activity of the human histone deacetylase.

46. The method of claim 45 wherein the step of contacting is in a cell.

47. The method of claim 45 wherein the cell is *in vitro*.

48. The method of claim 45 wherein the step of contacting is in a cell-free system.

49. A method of screening for agents which modulate an activity of a human histone deacetylase, comprising the steps of:

contacting a test compound with a product encoded by a polynucleotide which comprises the nucleotide sequence shown in SEQ ID NO: 1; and

detecting binding of the test compound to the product, wherein a test compound which binds to the product is identified as a potential agent for regulating the activity of the human histone deacetylase.

- 5 50. The method of claim 49 wherein the product is a polypeptide.
51. The method of claim 49 wherein the product is RNA.
- 10 52. A method of reducing activity of a human histone deacetylase, comprising the step of:
- contacting a cell with a reagent which specifically binds to a product encoded by a polynucleotide comprising the nucleotide sequence shown in SEQ ID NO: 1, whereby the activity of a human histone deacetylase is reduced.
- 15 53. The method of claim 52 wherein the product is a polypeptide.
54. The method of claim 53 wherein the reagent is an antibody.
- 20 55. The method of claim 52 wherein the product is RNA.
56. The method of claim 55 wherein the reagent is an antisense oligonucleotide.
57. The method of claim 56 wherein the reagent is a ribozyme.
- 25 58. The method of claim 52 wherein the cell is *in vitro*.
59. The method of claim 52 wherein the cell is *in vivo*.
- 30 60. A pharmaceutical composition, comprising:

a reagent which specifically binds to a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2; and

a pharmaceutically acceptable carrier.

5

61. The pharmaceutical composition of claim 60 wherein the reagent is an antibody.

62. A pharmaceutical composition, comprising:

10

a reagent which specifically binds to a product of a polynucleotide comprising the nucleotide sequence shown in SEQ ID NO: 1; and
a pharmaceutically acceptable carrier.

15

63. The pharmaceutical composition of claim 62 wherein the reagent is a ribozyme.

64. The pharmaceutical composition of claim 62 wherein the reagent is an antisense oligonucleotide.

20

65. The pharmaceutical composition of claim 62 wherein the reagent is an antibody.

66. A pharmaceutical composition, comprising:

25

an expression vector encoding a polypeptide comprising the amino acid sequence shown in SEQ ID NO: 2; and

a pharmaceutically acceptable carrier.

30

67. The pharmaceutical composition of claim 66 wherein the expression vector comprises SEQ ID NO: 1.
- 5 68. A method of treating a histone deacetylase dysfunction related disease, wherein the disease is cancer comprising the step of:
- administering to a patient in need thereof a therapeutically effective dose of a reagent that modulates a function of a human histone deacetylase, whereby symptoms of the histone deacetylase dysfunction related disease are ameliorated.
- 10 69. The method of claim 68 wherein the reagent is identified by the method of claim 36.
- 15 70. The method of claim 68 wherein the reagent is identified by the method of claim 45.
71. The method of claim 68 wherein the reagent is identified by the method of claim 49.

Fig. 1

atggggaccgcgcttgtgtaccatgaggacatgacggccacccggctgctctg
ggacgaccccgagtgcgagatcgagcgtcctgagcgcctgaccgcagccctgg
atcgccctgcggcagcgcggcctggaacagaggtgtctgcggttgtcagcccgc
gaggcctcggaagaggagctgggcctggtgcacagcccagagtatgtatccct
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aaacacgggctacacaggatcctcgtcgtggactgggatgtgcacccatggcca
ggggatccagtatctctttgaggatgaccccagcgtcctttacttctcctggc
accgctatgagcatgggcgcttctggcctttcctgcgagagtgcagatgcagac
gcagtggggcggggacagggcctcggttccactgtcaacctgcccctggaacca
ggttgggatgggaaacgctgactacgtggctgccttccctgcacctgctgctcc
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caggtgaacagtggtatagcagccactccagcctctgctgcagcagccacct
ggatgtggctgttcggagaggcctgtcccacggagcccagaggctgctgtgcg
tggccctgggacagctggaccggcctccagacctcgcccatgacgggaggagt
ctgtggctgaacatcaggggcaaggaggcggtgcccctatccatgttccatgt
ctccacgccactgccagtgatgaccggtggtttcctgagctgcatcttgggct
tgggtgctgcccctggcctatggcttccagcctgacctgggtgctgggtggcgctg
gggcctggccatggcctgcagggccccccacgctgcactcctggctgcaatgct
tcgggggctggcagggggccgagtcctggccctcctggaggagaactccacac
cccagctagcagggatcctggcccgggtgctgaatggagaggcacctcctagc
ctaggcccttccctctgtggcctcccagaggacgtccaggccctgatgtacct
gagagggcagctggagcctcagtgggaagatggttgacgtgccatcctcacctgg
tggcttga

Fig. 2

MGTALVYHEDMTATRLLWDDPECEIERPERLTAALDRLRQRGLEQRCRLRSAR
EASEEELGLVHSPEYVSLVRETQVLGKEELQALSGQFDAIYFHPSTFHCARLA
AGAGLQLVDAVLTGAVQNGLALVRPPGHGQRAAANGFCVFNNVAIAAAHAKQ
KHGLHRILVVDWDVHHGQGIQYLFEDDPSVLYFSWHRYEHGRFWPFLRESAD
AVGRGQGLGFTVNL PWNQVGMGNADYVAAFHLHLLPLAFEFDPVLVLSAGFD
SAIGDPEGQM QATPECF AHLTQLLQVLAGGRVCAVLEGGYHLES LAESVCMTV
QTLLGDPAPPLSGPMAPCQRCEGSALESIQSARAAQAPHWKS LQQQDVTAVPM
SPSSHSP EGRPPPLLPGGPVCKAAASAPSSLLDQPC LCPAPSVRTAVALTTPD
ITLVLPDPVIQQEASALREETEAWARPHE SLAREEALTALGKLLYLLDGMLDG
QVNSGIAATPASAAAATLDVAVRRGLSHGAQRLLCVALGQLDRPPDLAHDGRS
LWLNIRGKEAAALSMFHVSTPLPVMTGGFLSCILGLVLPLAYGFQPDVLVVAL
GPGHGLQGPHAALLAAMLRLAGGRVLALLEENSTPQLAGILARVLNGEAPPS
LGPSSVASPEDVQALMYLRGQLEPQWKMLQCHPHLVA

Fig. 3

MLASNSDGASTSVKPSDDAVNTVTPWSILLTNNKPMMSGSENTLNNE SHEMSQI
LKKSGLCYDPRMRFHATLSEVDDHPEDPRRVLRVF EAIKKAGYVSNVPSPSDV
FLRI PAREATLEELLQVHSQEMYDRVTNTEKMSHEDLANLEKISDSL YYNNE
AFCARLACGSAIETCTAVVTGQVKNAFAVVRPPGHHAEPHKPGGFCLFNNVSV
TARSM LQRFDPDKIKRVLIVDWDIHHGNGTQMAFYDDPNVLYVSLHRYENGRFY
PGTNYGCAENCGEGPGLGRTVNI PWSCAGMGDGDYIYAFQRVVMPVAYEFDPD
LVIVSCGFDAAGDHIGQFLLTPAAYAHMTQMLMGLADGKVFI SLEGGYNLDS
IST SALAVAQSLLGI PPGR LH TTYACPQAVATINHVTKIQSQYWRCMRPKHFD
ANPKDAHVDR LHDVIRTYQAKKLFEDWKITNMPILRDSVSNVFNNQVLCSSNF
FQKDNLLVIVHESPRVLGNGTSETNVLNLNDSLLVDPVSLYVEWAMQQDWGLI
DINIPEVVT DGENAPVDILSEVKELCLYVWDNYVELSISKNIFFIGGGKAVHG
LVNLASSRNVSDRVKCMVNFLGTEPLVGLKTASEEDLPTWYYRHSLVFVSSSN
ECWKKAKRAKRRYGR LMQSEHTETSDMMEQHYRAVTQYLLHLLQKARPTSQ

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Fig. 4

MTSTGQDSTTTTRQRRSRQNPOQSPQDSSVTSKRNIKKGAVPRSI PNLAEVKKK
GKMKKLGQAMEEDLIVGLQGMDLNLEAEALAGTGLVLDEQLNEFHCLWDDSP
EGPERLHAIKEQLIQEGLLDRCVSFQARFAEKEELMLVHSLEYIDLMETTQYM
NEGELRVLADTYDSVYLHPNSYSCACLASGSVLRLVDAVLGAEIRNGMAIIRP
PGHHAQHSLMDGYCMFNHVAVAARYAQQKHRIIRVLI VDWVDVHHGQGTQFTFD
QDPSVLYFSIHRYEQGRFWPHLKASNWSTTGFGQGQGYTINVPWNQVGMRDAD
YIAAFLHVLLPVALEFQPQLVLVAAGFDALQGDPKGEMAATPAGFAQLTHLLM
GLAGGKLILSLEGGYNLRALAEGVSASLHTLLGDPCPMLES PGAPCRSAQASV
SCALEALEPFWEVLVRSTETVERDNMEEDNVEESEEEGPWEPPVLPILTWPVL
QSRTGLVYDQNMNHCNLWDSSHPEVPQRILRIMCRLEELGLAGRCCLTLTPRP
ATEAELLTCHSAEYVGHLRATEKMKTRELRHRESSNFDSIYICPSTFACAQLAT
GAACRLVEAVLSGEVLNGAAVVRPPGHHAEQDAACGFCFFNSVAVAARHAQTI
SGHALRILIVDWVDVHHGNGTQHMFEEDPSVLYVSLHRYDHGTFFPMGDEGASS
QIGRAAGTGFTVNVAVNGPRMGDADYLAAWHRLVLP IAYEFNPVLVLSAGFD
AARGDPLGGCQVSPEGYAHLTHLLMGLASGRIILILEGGYNLTSESMAACT
RSLGDPPLLTLP RPPLSGALASITETIQVHRRYWRSLRVMKVEDREGPSS
KLVTKKAPQPAKPRLAERMTTREKKVLEAGMGKVT SASFGEESTPGQTNSETA
VVALTQDQPSAATGGATLAQTISEAAIGGAMLGQTTSEEAVGGATPDQTTSE
ETVGGAILDQTTSEDAVGGATLGQTTSEEAVGGATLAQTISEAMEGATLDQT
TSEEAPGGTELIQTPLASSTDHQTPTSPVQGTTPQISPSTLIGSLRTLLEGS
ESQGASESQAPGEENLLGEAAGGQDMADSMMLMQGSRGLTDQAI FYAVTPLPWC
PHLVAVCPIPAAGLDVTQPCGDCGTIQENWVCLSCYQVYCGRYINGHMLQH HG
NSGHPLVLSYIDL SAWCYQCAYVHHQALLDVKNIAHQNKFGEDMPHPH

Fig. 5

TGCGGTGTAAATTCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATT CAGCACCCGGGCCAAGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGT CAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCAG
CTCAGGAAACCACCGGTCATCACTGGCAGTGGCGTGGAGACATGGAACATGGA
TAGGGCAGCCGCTCCTTGCCCCTGATGTT CAGCCACAGACTCCTCCCGTCAT
GGGCGAGGTCTGGAGGCCGGTCCAGCTGTCCCAGGGCCACGCACAGCAGCCTC
TGGGCTCCGTGGGAC

Fig. 6

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATT CAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGT CAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCAG
CTCANGAAACCACCGGTCATCACTGGCAGTGGCGTGGAGACATGGAACATGGA
TAGGGCAGCCGCCTCCTTGCCCCCTGATGTT CAGCCACAGACTCCTCCCGTCAT
GGGCGAGGTCTGGA

Fig. 7

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATT CAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCA
GGAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGC
ACCAGGT CAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCA
GCTCAGGAAACCACCGGTCATCACTGGCAGTGGCGTGGAGACATGGAACATGG
ATAGGGCAGCCGCCTCCTTGCCCCCTGATGTT CAGCCACAGACTCCTCCCGTCA
TGGGCG

Fig. 8

CGTGCGGTGTCATTTCTGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGC
CACCAGGTGAGGATGGCACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTC
TCAGGTACATCAGGGCCTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCT
AGGCTAGGAGGTGCCTCTCCATT CAGCACCCGGGCCAGGATCCCTGCTAGCTG
GGGTGTGGAGTTCTCCTCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCC
GAAGCATTGCAGCCAGGAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGC
CCCAGCGCCACCAGCACCAGGT CAGGCTGGAAGCCATAGGCCAGGGGCAGCAC
CAAGCCCAAGATGCAGCTCAGGAAACCACCGGTCATCACTTGCAGTGGCGTGG
AGACATGGAACATGGATAGGGCAGCCGCCTCCTTGCCCCCTGATGTT CAGCCAC
AGACTC

Fig. 9

AAGCTTGCGGCCGCGGGGCGCTGGCGTGCGGTGTCATTTCTGCGGTGTAAATG
CTCCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGGCACTGCAACATCT
TCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGCCTGGACGTCCTCT
GGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCTCTCCATTCAGCAC
CCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTGGACCAGGGGCGAAG
ACGGAAGCAGTCACTGGTCCTTCCCCTCGTCCCACCCCGCAGCACCTNCACCC
TGCCCAGCTTACCTCCTCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCC
GAAGCATTGCAGCCAGGAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGC
CCCAGCGCCACCAGCACCCAGGTGAGGCTGGAAGCCATAGGCCAGGGGCAGCAC
CAAGCCCAAGATGCAGCTCAGGAAACCACCGGTCACTACTGGCAGTGGCGTGG
AGACATGGAACATGGATAGGGCAGCCGCCTCCTTTCCCCTGATGTTACGCCAC
AGACTCCCGTCATGGGCGAGGTCTGGA

Fig. 10

TGCGGTGTAAATGCTCCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTCAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTGG
ACCAGGGGCGAAGACGGAAGCAGTCACTGGTCCTTCCCCTCGTCCCACCCCGC
AGCACCTCCACCCTGCCAGCTTACCTCCTCCAGGAGGGCCAGGACTCGGCCC
CCTGCCAGCCCCCGAAGCATTGCAGCCAGGAGTGCAGCGTGGGGGCCCTGCAG
GCCATGGCCAGGCCCCAGCGCCACCAGCACCCAGGTGAGGCTGGAAGCCATAGG
CCAGGGGCAGCACCAAGCCCAAGATGCAGCTCANGAAACCACCGGTCACTACT
GGCAGTGGCGTGGAGACATGGAACATGGATAGGGCAGCCGCCTCCTTGCCCCCT
GATGTTACGCCACAGACTCCTCCCGTCATG

Fig. 11

TGCGGTGTAAATGCTCCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTCAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCAG
CTCAGGAAACCACCGGTCACTACTGGCAGTGGCGTGGAGACATGGAACATGGA
TAGGGCAGCCGCCTCCTTGCC

Fig. 12

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAAGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCAG
CTCAGGAAACCACCGGTCATCACTGGCAGTGGCGTGGAGACATGGAACATGGA
TAGGGCAG

Fig. 13

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCAG
CTCAGGAAACCACCGGTCATCACTTGCAAGTGGCGTGGAGACATGGAACATGG
ATAGGGCAGCCGCCTCCTTGCCCCCTGATGTTAGGCCACAGACTCCTCCCGTCA
TGGGCG

Fig. 14

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGGTGAAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAAGCCCAAGATGCAG
CT

Fig. 15

AGCGGCCGCGGGGCGCTGGCGTGCGGTGTCATTTCTGCGGTGTAAATGCTCCC
ACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGGCACTGCAACATCTTCCAC
TGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGCCTGGACGTCCTCTGGGGA
GGCCACAGAGGAAGGGCCTANGCTAGGAGGTGCCTCTCCATTAGCACCCGGG
CCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCCTCCAGGAGGGCCAGGACT
CGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAGGAGTGCAGCGTGGGGGCC
CTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCACCAGGTGCTGGAAGC
CATAGGCCAGGGGCCACACCAAGCCCAAG

Fig. 16

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGCTGGAAGCAT

Fig. 17

TGCGGTGTAAATGCTCCACCTTGGGCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGCTGGAA

Fig. 18

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTTCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTGAGGC

Fig. 19

TGCGGTGTAAATGCTCCACCTTGGCCGATTTCAAGCCACCAGGTGAGGATGG
CACTGCAACATCTTCCACTGAGGCTCCAGCTGCCCTCTCAGGTACATCAGGGC
CTGGACGTCTCTGGGGAGGCCACAGAGGAAGGGCCTAGGCTAGGAGGTGCCT
CTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGGAGTCCTCC
TCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATTGCAGCCAG
GAGTGCAGCGTGGGGGCCCTGCAGGCAGTGGCCAGGCCCCAGCGCCACCAGCA
CCAGGTCAGGCTGGAAGC

Fig. 20

AGGTGCCTCTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGG
AGTTCTCCTCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATT
GCAGCCAGGAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGC
CACCAGCACCAGGTCAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAGCCCA
AGATGCAGCTCAGGAAACCACCGGTCATCACTGGCAGTGGCGTGGAGACATGG
AACATGGATAGGGCAGCCG

Fig. 21

AGGTGCCTCTCCATTAGCACCCGGGCCAGGATCCCTGCTAGCTGGGGTGTGG
AGTTCTCCTCCAGGAGGGCCAGGACTCGGCCCCCTGCCAGCCCCCGAAGCATT
GCAGCCAGGAGTGCAGCGTGGGGGCCCTGCAGGCCATGGCCAGGCCCCAGCGC
CACCAGCACCAGGTCAGGCTGGAAGCCATAGGCCAGGGGCAGCACCAGCCCA
AGATGCAGCTCAGGAAACCACCGGTCATCACTTGCAGTGGCGTGGAGACATGG
AACATGGATAGGGCAGC

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Fig. 22

BLASTP - alignment of 355_protein against swiss|P56523|HDA1_SCHPO

HISTONE DEACETYLASE CLR3.//:tremblnew|AL391034|SPBC800_3 gene: "clr3";
product: "putative histone deacetylase"; S.pombe chromosome II cosmid
SPU41410.//:trembl|AF064207|AF064207_1 gene: "clr3"; product: "putative
histone deacetylase"; Schizosaccharomyces pombe putative histone deacetylase
(clr3) gene, complete cds.//:pironly|T43797|T43797 probable histone
deacetylase (EC 3.5.1.-) clr3 - fission yeast
(Schizosaccharomyces pombe) gene: "clr3"; product: "putative
histone deacetylase"; Schizosaccharomyces pombe putative histone deacetylase
(clr3) gene, complete cds.//:gpnew|AL391034|9716243 gene: "clr3"; product:
"putative histone deacetylase"; S.pombe chromosome II cosmid SPU41410.

This hit is scoring at : 4e-76 (expectation value)

Alignment length (overlap) : 354

Identities : 42 %

Scoring matrix : BLOSUM62 (used to infer consensus pattern)

Database searched : nrdb

```

Q: 26 ERPERLTAALDRLRQRLQRC-----LRLSAREASEEELGLVHSPEYVSLVRETQVL
   E P.R:.....:G. ... LR:AREA: EEL VHS.E... V..T: :
H: 79 EDPRRVLRVFEAIKAGYVSNVPSDVFRLRIPAREATLEELLQVHSQEMYDRVTNTEKM

GKEELQALSGQFDIYFHPSTFFHCARLAAGAGLQLVDVLTGAVQNGLALVRPPGHHGQR
..E:L. L. D:Y::: CARLA.G:::..AV:TC.V:N..A:VRPPGHH.:
SHEDLANLEKISDSLYNNESAFCARLACGSAIETCTAVVTGQVKNAFAVVRPPGHHAEF
AAANGFCVFNNVAIAAAHAKQKHG--LHRILVVDWDVHHGQGIQYLFEDDPSVLYFSWHR
...GFC:FNNV::A... Q::: R:L:VDWD:HHG.G.Q..F DDP:VLY.S HR
HKPGGFCFLFNNVSVTARSMLQRFDPDKIKRVLIVDWDIHHNGGTQMAFYDDPNVLYVSLHR
YEHGRFWPFLRESADAVGRGQGLGFTVNLPNWQVGMGNADYVAFLHLLPLAFEFDPPE
YE:GRF:P... A: .G.G.GLG TVN:PW: .GMG:DY: AF :::P:A:EFDP:
YENGRFYPTNYGCAENCGEGLGRTVNIPIWSCAGMGDGDYIYAFQRVVMPVAYEFDPD

```

Fig. 22 (continued)

```
LVLVSAGFDSAIGDPEGQMQATPECFAHLTQLLQVLAGGRVCAVLEGGYHLESIAESVCM
LV:VS.GFD:A.GD GQ. .TP.:AH:TQ:L. LA.G:V . LEGGY:L:S:..S...
LVIVSCGFDAAAGDHIGQFLLTPAAYAHMTQMLMGLADGKVFISLEGGYNLDSISTSALA

TVQTL LGDPAPPLSGPMAPCQRCESALESIQSARAAQAPHWKSLOQQQDVTAVP      370
..Q:LLG P. L. .A Q A:..I.....Q:..W:.....A P
VAQSLLGIPPGRLHTTYACPQ-----AVATINHVTKIQSQYWRCMRPKHFDANP      427
```

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Fig. 23

BLASTP - alignment of 355 protein against trembl|AF132609|AF132609_1
 product: "histone deacetylase 6"; Homo sapiens histone deacetylase 6 mRNA,
 complete cds. //:trmbl|AJ011972|HSA011972_1 gene: "jm21"; product: "histone
 deacetylase-like protein"; Homo sapiens mRNA for histone deacetylase-like
 protein (JM21) //:gp|AJ011972|3776071 gene: "jm21"; product: "histone
 deacetylase-like protein"; Homo sapiens mRNA for histone deacetylase-like
 protein (JM21). //:gp|AF132609|4754911 product: "histone deacetylase 6";
 Homo sapiens histone deacetylase 6 mRNA, complete cds.

This hit is scoring at : 5e-112 (expectation value)

Alignment length (overlap) : 392

Identities : 51 %

Scoring matrix : BLOSUM62 (used to infer consensus pattern)

Database searched : nrdb

```

Q:      2  GTALVYHEDMTATRLWDDPECEIERPERLTAALDRLRQRLSAREASEEELG
          GT.LV..E:... ..LWDD.  E  PERL A. : : L Q.GL .RC:...AR A.:EEL
H:      85  GTGLVLDEQLNEFHCLWDDSFPE--GPERLHAIKEQLIQEGLLDRCVSFQARFAEKEELM

          LVHSPEYVSLVRETQVLGKEELQALSGQFDAIYFHPSTFFHCARLAAGAGLQLVDAVL TGA
          LVHS  EY:.L:..TQ:..: EL:.L:..:D:..:Y.HP:..:CA LA:G: L:LVD AVL ..
          LVHSLEYIDLMETTQYMNEGELRVLADTYDSVYLHPNSYSCACLASGSVLRLLVDAVLGAE

          VQNGLALVRPPGHHGQRAAANGFCVFNNVAIAAAHAKQKHGLHRILVVDWDVHHGQGIQY
          : :NG:A: :RPPGHH.Q:..:G:C:FN:VA:AA.:A:QKH : :R:L:VDWDVHHGQG.Q:
          IRNGMAIIRPPGHHQHSMDGYCMFNHVAVAARYAQQKHRIIRVLIVDWDVHHGQGTQF

          LFEDDPSVLYFSWHRYEGRFWPFLRESADADAVGRGQGLGFTVNLPNQVGMGNADYVAA
          .F: .DPSVLYFS HRYE.GRFWP.L:..S: ..G GQG G:T:N:PWNQVGM :ADY:AA
          TFDQDPSVLYFSIHRYEQGRFWPHLKASNWSTTGFGQGGQYTYINVPWNQVGMRDADYIAA

          FLHLLPLAFEFDPPELVLSAGFDSAIGDPEGQMQATPECFAHLTQLLQVLACGRVC AVL
          FLH:LLP:A.EF.P:LVLV:AGFD: . GDP:G:M.ATP. FA.LT.LL. LAGG:..L
          FLHVLPLVALEFQPLVLVAAGFDALQGDPKGEMAATPAGEFAQLTHLLMGLAGGKLILSL
  
```

Fig. 23 (continued)

EGGYHLESIAESVCMVTQTLLGDPAPPPLSGPMAPCQRCESALESIQSARAAQAPHWKSL
 EGGY:L.:LAE.V.:.TLLGDP.P L.P APC: SA S:..A .A .P.W: L
 EGGYNLRALLAEGVSASLHTLLGDP.CPMLESPGAPCR---SAQASVSCALEALEPFWFWEVL

QQQDVTA---VPMSPSSHSPGPRP--PPLLIP 387
 :..T. :..S.E P PP:LP
 VRSTETVERDNMEEDNVEESEESEEGPWPPVLP 470

This hit is scoring at : 2e-98 (expectation value)

Alignment length (overlap) : 365

Identities : 51 %

Scoring matrix : BLOSUM62 (used to infer consensus pattern)

Database searched : nrdb

Q: 3 TALVYHEDMTATRLLLWDDPECEIERPERLTAALDRLRQRLSAREASEEELGL
 T.LVY.:.M. LWD. . E: P:R:..: RL.: GL. RCL.L.:R.A:E.EL .
 H: 481 TGLVYDQNMNMNHCNLWDSHHPEV--PQIRLMCRLEELGLAGRCLTLTPRPATEAELLT
 VHSPEYVSLVRETQVLGKEELQALSGQFDIYFHPSTFFHFCARLAAGAGLQLVDAVLTGAV
 .HS.EYV. :R.T: : ..EL.. S..FD:IY. PSTF CA:LA.GA.:LV:AVL:G.V
 CHSAEYVGHLRATEKMKTREILHRESSNFDSIYICPSTFACAQLATGAACRLVEAVLSGEV

QNGLALVRPPGHHGQRAAANGFCVFNNVAIAAAHAKQKHG-LHRILVVDWDVHHGQGIQY
 NG.A:VRPPGHH.:.AA GFC.FN:VA:AA.HA.:.G . RIL:VDWDVHHG.G.Q:
 LNGAAVVRPPGHHAEQDAACGFCFFNSVAVAARHAQTISGHALRILIVDWDVHHGNGTQH

LFEDDDPSVLYFSWHRYEHGRFWPFLRESADADA VGRGQGLGFTVNLPNQVGMGNADYVAA
 :FEDDDPSVLY.S HRY:HG.F:P. E. :.:GR.:G.GFTVN:.WN MG:ADY:AA
 MFEDDDPSVLYVSLHRYDHGTFPFPMGDEGASSQIGRAAGTGFTVNVWNGPRMGDADYLAA

FLHLLPLAFEFDPPELVLSAGFDSAIGDPEGQMQATPECF AHLTQLLQVLAGRVC AVL
 :.L:LP:A:EF:PELVLSAGFD:A GDP G .Q.:PE :AHLT.LL. LA.GR:..:L
 WHRLVLPPIAYEFNPELVLSAGFDAARGDPLGGCQVSPEGYAHLTHLLMGLASGRILLIL

Fig. 23 (continued)

EGGYHLESLAESVCM TVQTLLGDPAPPLSGPMAPCQRCESALESIQSARAAQAPHWKSL
 EGGY:L.S::ES:::LLGDP.P.L: P.P...S.E:IQ R. :W:SL
 EGGYNLTSESMAACTRSLGDPPLLLTLPRPPLSGALASITETIQVHRR-----YWRSL

QQQDV	366
:..V	
RVMKV	839

Fig. 24

BLASTP - alignment of 355_{protein} against pdb|1C3P|1C3P-A
hdp (histone deacetylase-like protein)

This hit is scoring at : 2e-20 (expectation value)

Alignment length (overlap) : 285

Identities : 27 %

Scoring matrix : BLOSUM62 (used to infer consensus pattern)

Database searched : nrdb

```

Q: 50 LSAREASEEELGLVHSPYVSLVRETQVL-----GKEELQALSGQFDAIYFHPSTFHCAR
   :R.A::EEL L.H::Y:::E:: G..E . :.G. :. : : :.F :.
H: 46 IKSRLPATKEELLFHTEDYINTLMEACQCVPKGAAREKYNIGGYENPVSY--AMFTGSS

   LAAGAGLQLVDAVLTGAVQNGLALVRPPG--HHGQRAAANGFCVFNNVAIAAAHAKQKHG
   LA.G: :Q:::L.G V. ..P.G HH. :.ANGFC..NN A: : : : :K G
   LATGSTVQAIEEFLKGNVA-----FNPAGGMHHAFAKSRANGFCYINNPAGVIEYLRKK-G

   LHRILVVDWDVHHGQGIQYLFEDDPSVLYFSWHRYEHRFWPFLRESADAVGRGQGLGF
   ..RIL.:D D.HH .G:Q .F D...V...S H: ..F PF :. :. :G.G:G G:
   FKRILYIDLDAHHCDGVQEAIFYDTDQVFLSLHQSPYAF-PF-EKGFLEEIGEKGKGY

   TVNLPWNQVGMGNADYVAAFLHLLPLAFEFDPDELVLVSAGFDSAIGDPGQMQATPECF
   .:N:P : G::: :A. . L :. F:PE:L:..G D.: D : : : :.F
   NLNIPLPK-GLNDNEFLFALEKSLEIVKEVFEPEVYLLQLGLTDPDLEDYLSKFNLNVAF

   AHLTQLQLAGGRVCAVLEGGYHLESLSAESVCMTVQTL LGDPAP 327
   ... : : : G V : GGYH :LA.: :. .L G ..P
   LKAFNIVREVFGEV-YLGGGGYHPYALARAWTLIWCELSGREVP 318

```

Fig. 25

HMMPFAM - alignment of 355_protein against pfam|hmm|Hist_deacetyl|Histone deacetylase family

This hit is scoring at : 342.8 E=3.7e-99

Scoring matrix : BLOSUM62 (used to infer consensus pattern)

```
Q: 4 ALVYHEDMTATRLLLWDDPECEIERPERLTAALDRLRQGLEQRCLRLS-AREAEEEEELGL
H: ..VY:::..E.PERL...: L : GL :: : R:A:EEL L
1 gyvydpevlnehckisygathPenperlrlihellelleyglkkmeivtnprkatdeelll
VHSPEYVSLVRETQVLGKEELQA-L-----SQFDA---IYFHPSTFFHCARLAAGAG
VHS: YV:.....EEL:. .F:. . . . . . ARLA.G...
vHsedyvefleslsktnleekgtkillleielkyfnkgdDtpvfaglyeearlavGgs
LQLVDAVLTGAVQNGLALVRPPGHGHGQRAAANGFCVFNNVAIAAAHAHQKH--GLHRILV
L:L.D:L.G:N. PGHH:::A:GFC.FNNVAIA.:K: :R:L:
leladrllegeIdnafnwagGPgHHakkeasGFCyfNnVAiAiKyllkkypayvkrVli
VDWDVVHHGGIQYLFEDDPSVLyFSWHRYEHGRFWPFLresDADAVGRGQGGLFTVNLPW
:D:DVHHG.G.Q:F DD.VL.S:H:Y.G.F:P.D...:G:G:G G:T:N:P
iDfdVHHGDGTQeiFYdddrVltvSFHKygkGeFFPGT..GditeigkgkGgytlniPl
NQVGGMGNADYVAAFHLHLLPLAFEFDPPELVLSAGFDSAIGDP--EGQMqATPECFAHLT
N: G....Y:AF H:: P:: F.P:::SAGFD:..GDP G....T E :...
nedgtdDesylsafkhviepvlegFkpdaivisaGfDalYgdptqlgsfnLtiegymv
QLLQVLA----GGRVCavLEGGYHLE---SLAESVCMTVTQTLLG 323
:L: LA .G :..VLEGGY L. :A...:::LLG
rflkslaqhkcdbgpllvLEGGYtlraianvarcwiAltggllg 342
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Fig. 26 Human histone deacetylase mRNA expression profiling - RT PCR

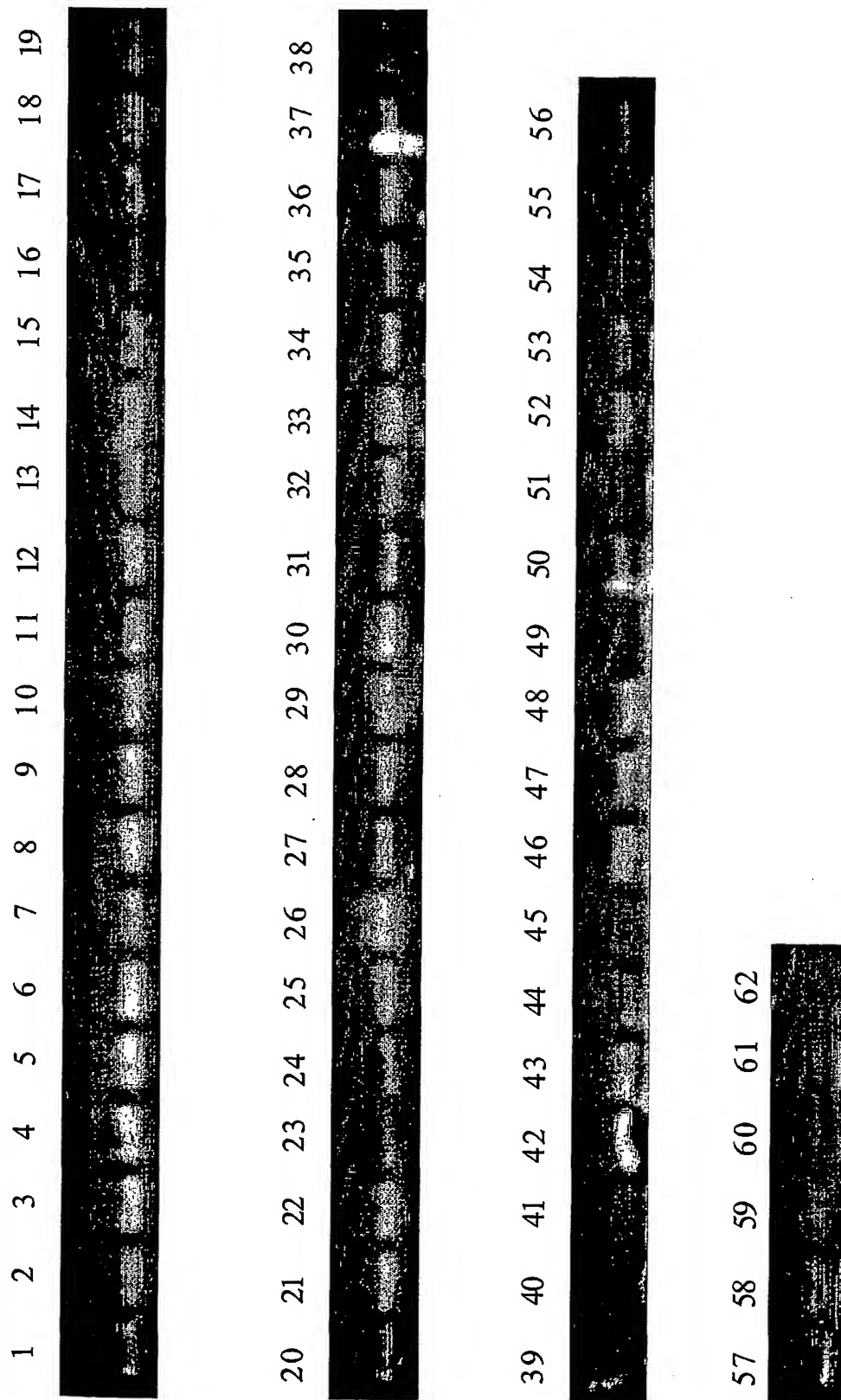
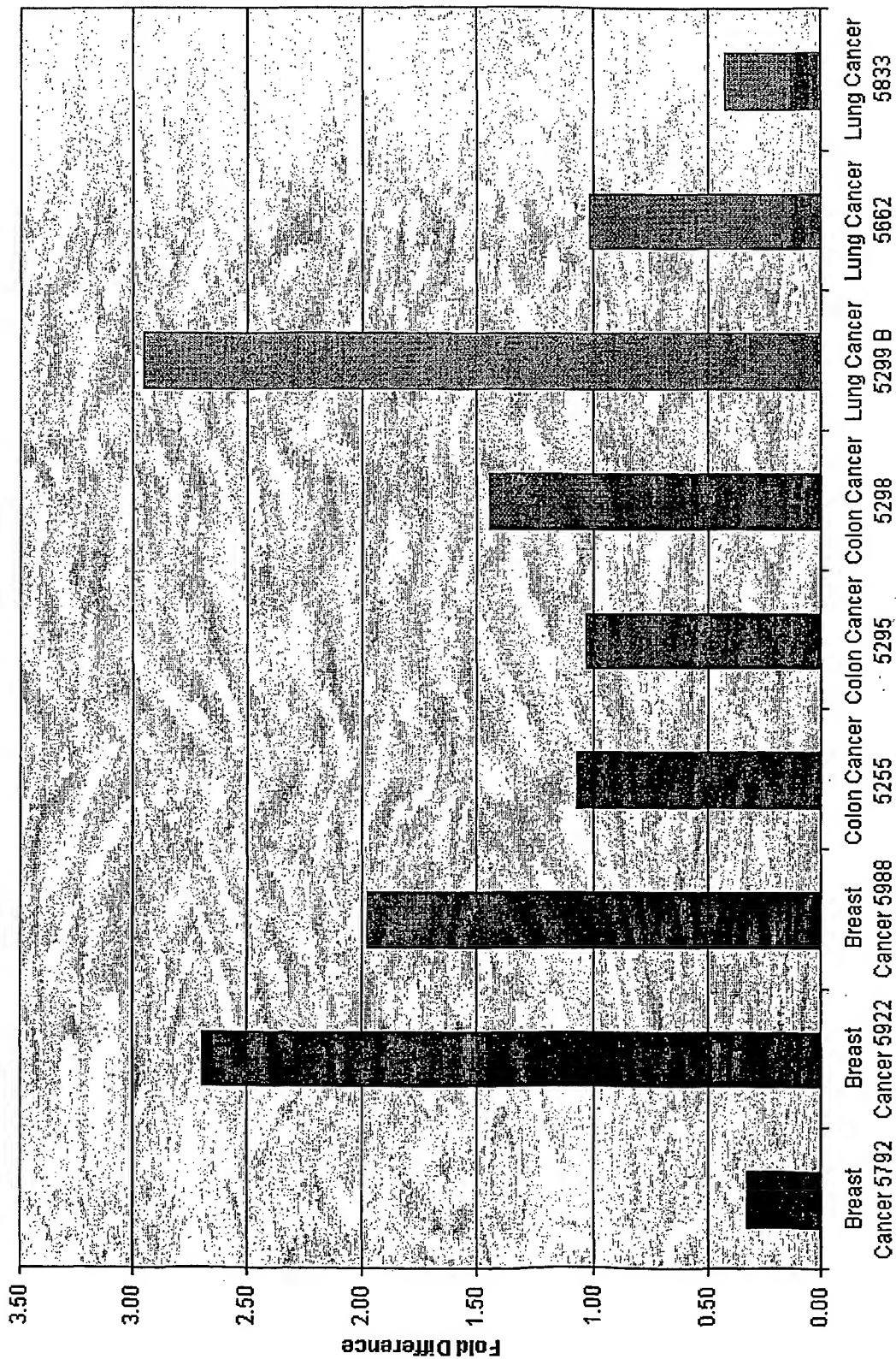
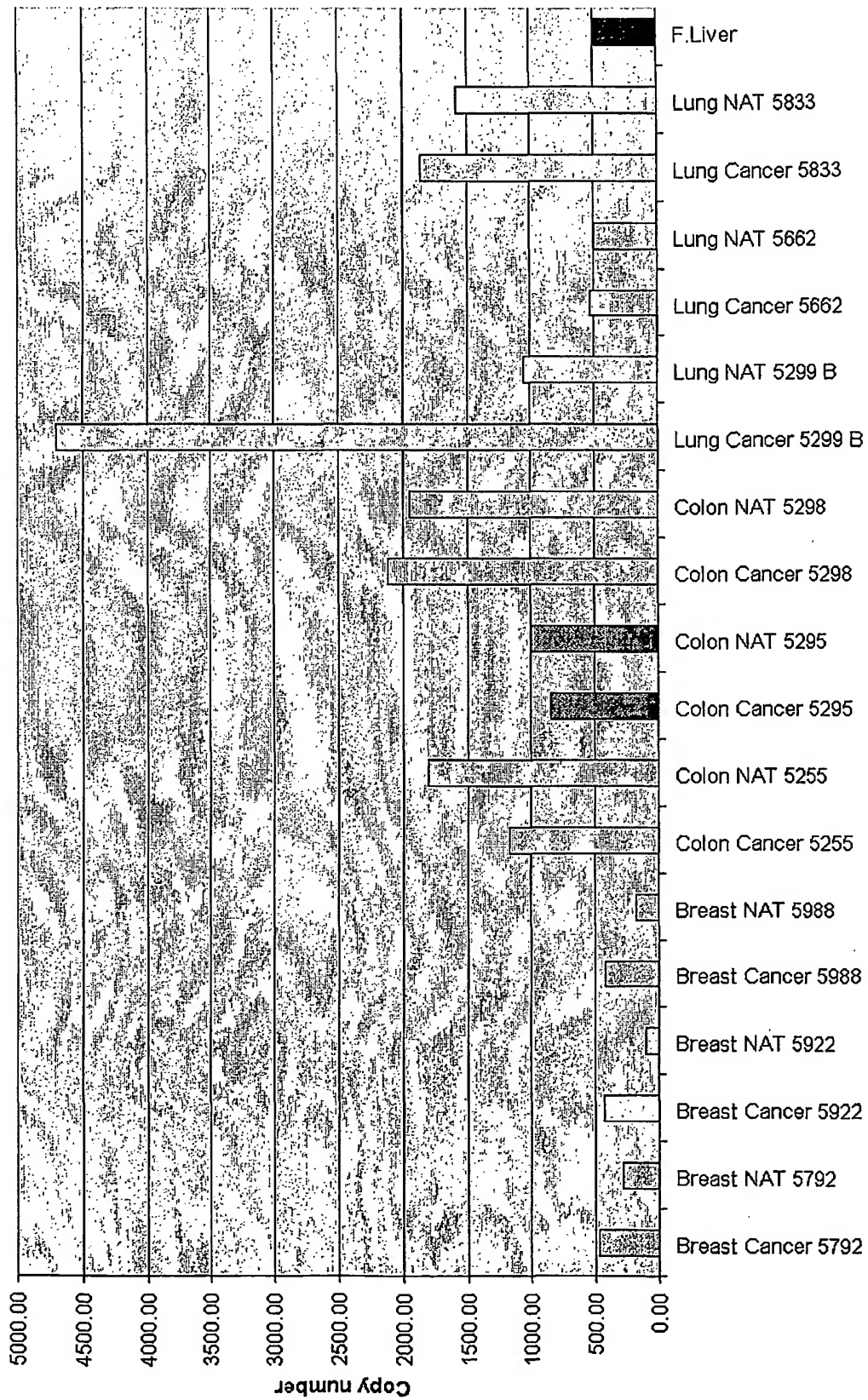


Fig. 27 Human histone deacetylase mRNA expression profiling - Taqman (normalized to 18S RNA)



- 18/18 -

Fig. 28 Human histone deacetylase mRNA expression profiling - Taqman (copy number)



- 1 -

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<130> LI0173 Foreign Countries

<150> US 60/239,928

<151> 2000-10-13

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<213> Homo sapiens

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cgcggcctgg aacagaggtg tctgcggttg tcagcccgcg aggcctcgga agaggagctg      180
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gaggagctgc aggcgctgtc cggacagttc gacgccatct acttccaccc gagtaccttt      300
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 35 40 45

Arg Leu Ser Ala Arg Glu Ala Ser Glu Glu Glu Leu Gly Leu Val His
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Ser Pro Glu Tyr Val Ser Leu Val Arg Glu Thr Gln Val Leu Gly Lys
 65 70 75 80

Glu Glu Leu Gln Ala Leu Ser Gly Gln Phe Asp Ala Ile Tyr Phe His
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Pro Ser Thr Phe His Cys Ala Arg Leu Ala Ala Gly Ala Gly Leu Gln
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Leu Val Asp Ala Val Leu Thr Gly Ala Val Gln Asn Gly Leu Ala Leu
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Val Arg Pro Pro Gly His His Gly Gln Arg Ala Ala Ala Asn Gly Phe
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Cys Val Phe Asn Asn Val Ala Ile Ala Ala Ala His Ala Lys Gln Lys
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His Gly Leu His Arg Ile Leu Val Val Asp Trp Asp Val His His Gly
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Gln Gly Ile Gln Tyr Leu Phe Glu Asp Asp Pro Ser Val Leu Tyr Phe
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Ser Trp His Arg Tyr Glu His Gly Arg Phe Trp Pro Phe Leu Arg Glu
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Ser Asp Ala Asp Ala Val Gly Arg Gly Gln Gly Leu Gly Phe Thr Val
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Asn Leu Pro Trp Asn Gln Val Gly Met Gly Asn Ala Asp Tyr Val Ala
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Gly Lys Leu Leu Tyr Leu Leu Asp Gly Met Leu Asp Gly Gln Val Asn
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Val Ala Leu Gly Gln Leu Asp Arg Pro Pro Asp Leu Ala His Asp Gly
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Met Phe His Val Ser Thr Pro Leu Pro Val Met Thr Gly Gly Phe Leu
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Ser Cys Ile Leu Gly Leu Val Leu Pro Leu Ala Tyr Gly Phe Gln Pro
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Asp Leu Val Leu Val Ala Leu Gly Pro Gly His Gly Leu Gln Gly Pro
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His Ala Ala Leu Leu Ala Ala Met Leu Arg Gly Leu Ala Gly Gly Arg
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Leu Ala Arg Val Leu Asn Gly Glu Ala Pro Pro Ser Leu Gly Pro Ser
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Glu Met Ser Gln Ile Leu Lys Lys Ser Gly Leu Cys Tyr Asp Pro Arg
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Met Arg Phe His Ala Thr Leu Ser Glu Val Asp Asp His Pro Glu Asp
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Pro Arg Arg Val Leu Arg Val Phe Glu Ala Ile Lys Lys Ala Gly Tyr
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Val Ser Asn Val Pro Ser Pro Ser Asp Val Phe Leu Arg Ile Pro Ala
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Arg Glu Ala Thr Leu Glu Glu Leu Leu Gln Val His Ser Gln Glu Met
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Tyr Asp Arg Val Thr Asn Thr Glu Lys Met Ser His Glu Asp Leu Ala
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Phe Cys Ala Arg Leu Ala Cys Gly Ser Ala Ile Glu Thr Cys Thr Ala
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Gly His His Ala Glu Pro His Lys Pro Gly Gly Phe Cys Leu Phe Asn
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His Arg Tyr Glu Asn Gly Arg Phe Tyr Pro Gly Thr Asn Tyr Gly Cys
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Ala Glu Asn Cys Gly Glu Gly Pro Gly Leu Gly Arg Thr Val Asn Ile
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Pro Trp Ser Cys Ala Gly Met Gly Asp Gly Asp Tyr Ile Tyr Ala Phe
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Gln Arg Val Val Met Pro Val Ala Tyr Glu Phe Asp Pro Asp Leu Val
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Ile Val Ser Cys Gly Phe Asp Ala Ala Ala Gly Asp His Ile Gly Gln
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Gly Leu Ala Asp Gly Lys Val Phe Ile Ser Leu Glu Gly Gly Tyr Asn
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Leu Asp Ser Ile Ser Thr Ser Ala Leu Ala Val Ala Gln Ser Leu Leu
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Gly Ile Pro Pro Gly Arg Leu His Thr Thr Tyr Ala Cys Pro Gln Ala
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Val Ala Thr Ile Asn His Val Thr Lys Ile Gln Ser Gln Tyr Trp Arg
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Cys Met Arg Pro Lys His Phe Asp Ala Asn Pro Lys Asp Ala His Val
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Glu Asp Trp Lys Ile Thr Asn Met Pro Ile Leu Arg Asp Ser Val Ser
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Asn Val Phe Asn Asn Gln Val Leu Cys Ser Ser Asn Phe Phe Gln Lys
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Leu Val Gly Leu Lys Thr Ala Ser Glu Glu Asp Leu Pro Thr Trp Tyr
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Tyr Arg His Ser Leu Val Phe Val Ser Ser Ser Asn Glu Cys Trp Lys
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Lys Ala Lys Arg Ala Lys Arg Arg Tyr Gly Arg Leu Met Gln Ser Glu
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Glu Val Lys Lys Lys Gly Lys Met Lys Lys Leu Gly Gln Ala Met Glu
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Glu Asp Leu Ile Val Gly Leu Gln Gly Met Asp Leu Asn Leu Glu Ala
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Glu Ala Leu Ala Gly Thr Gly Leu Val Leu Asp Glu Gln Leu Asn Glu
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Phe His Cys Leu Trp Asp Asp Ser Phe Pro Glu Gly Pro Glu Arg Leu
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Glu Gly Glu Leu Arg Val Leu Ala Asp Thr Tyr Asp Ser Val Tyr Leu
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His Pro Asn Ser Tyr Ser Cys Ala Cys Leu Ala Ser Gly Ser Val Leu
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Tyr Cys Met Phe Asn His Val Ala Val Ala Ala Arg Tyr Ala Gln Gln
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Lys His Arg Ile Arg Arg Val Leu Ile Val Asp Trp Asp Val His His
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Phe Ser Ile His Arg Tyr Glu Gln Gly Arg Phe Trp Pro His Leu Lys
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Ala Ser Asn Trp Ser Thr Thr Gly Phe Gly Gln Gly Gln Gly Tyr Thr
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Gln Leu Val Leu Val Ala Ala Gly Phe Asp Ala Leu Gln Gly Asp Pro
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Lys Gly Glu Met Ala Ala Thr Pro Ala Gly Phe Ala Gln Leu Thr His
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Gly Tyr Asn Leu Arg Ala Leu Ala Glu Gly Val Ser Ala Ser Leu His
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Thr Leu Leu Gly Asp Pro Cys Pro Met Leu Glu Ser Pro Gly Ala Pro
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Cys Arg Ser Ala Gln Ala Ser Val Ser Cys Ala Leu Glu Ala Leu Glu
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Thr Gly Leu Val Tyr Asp Gln Asn Met Met Asn His Cys Asn Leu Trp
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Gln His Met Phe Glu Asp Asp Pro Ser Val Leu Tyr Val Ser Leu His
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Trp Asn Gly Pro Arg Met Gly Asp Ala Asp Tyr Leu Ala Ala Trp His
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Ser Leu Arg Val Met Lys Val Glu Asp Arg Glu Gly Pro Ser Ser Ser
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(10) International Publication Number
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G01N 33/573

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GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI,
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ZA, ZW.

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patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,
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CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD,
TG).

Published:

— with international search report

(88) Date of publication of the international search report:
11 July 2002

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.



WO 02/030970 A3

(54) Title: HUMAN HISTONE DEACETYLASE GENE

(57) Abstract: Reagents which regulate human histone deacetylase and reagents which bind to human histone deacetylase gene products can play a role in preventing, ameliorating, or correcting dysfunctions or diseases including, but not limited to, cancer.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 01/11759

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C12N9/16 C12N5/10 C12N15/11 C12N15/55 C12N15/62
 C12N15/63 C07K16/40 A61K31/7088 A61K39/395 A61K48/00
 A61P35/00 C12Q1/34 C12Q1/68 G01N33/573

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EMBL, WPI Data, SEQUENCE SEARCH, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE EMBL 'Online! Accession Nr AL022328, 1 April 1998 (1998-04-01) COVILLE G: XP002192398 the whole document	1-71
A	WO 97 35990 A (PRESIDENT AND FELLOWS OF HARVARD COLLEGE) 22 October 1997 (1997-10-22) the whole document	1-71
A	WO 00 10583 A (SMITHKLINE BEECHAM CORPORATION (US)) 2 March 2000 (2000-03-02) the whole document	1-71



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

26 March 2002

Date of mailing of the international search report

17/04/2002

Name and mailing address of the ISA

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 NL - 2280 HV Rijswijk
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 Fax: (+31-70) 340-3016

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Piret, B

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 8,9,13-17,33,42,52,58-60,62,68-71 (all partially)

Present claims 8, 9, 13-17, 33, 42, 52, 58-60, 62 and 68-71 relate to reagents (and methods using these reagents), defined by reference to a desirable characteristic or property, namely a) the ability of said reagents to bind to a polypeptide comprising an amino-acid sequence at least 52% identical to SEQ ID N°2 or to a product (protein, RNA) encoded by SEQ ID N°1 (claims 8, 9, 13, 33, 42, 52, 58-60, 62), or b) the ability to modulate the function or activity of a human histone deacetylase (claims 14-16, 68-71).

The claims cover all compounds having this characteristic or property, whereas the application does neither provide support within the meaning of Article 6 PCT nor disclosure within the meaning of Article 5 PCT. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible.

Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the reagents by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible.

Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to : polynucleotides comprising the sequence SEQ ID N°:1 or encoding a polypeptide of sequence SEQ ID N°:2; fragments of, products (nucleic acids and proteins) encoded by, and vectors containing said polynucleotides; polypeptides comprising the sequence SEQ ID N°:2; screening methods using said polynucleotides or products encoded by these. Reagents able to bind or inhibit polypeptides comprising a sequence at least 52% identical to SEQ ID N°:2 were searched as antibodies directed against peptides having a sequence comprised in SEQ ID N°:2. Reagents able to bind polynucleotides comprising SEQ ID N°:1 were searched as antisense or ribozyme oligo- or polynucleotides comprising a sequence complementary to SEQ ID N°:1 or a fragment thereof.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 01/11759

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9735990	A	02-10-1997	AU 2990597 A	17-10-1997
			WO 9735990 A2	02-10-1997
WO 0010583	A	02-03-2000	EP 1105143 A1	13-06-2001
			WO 0010583 A1	02-03-2000
			US 2001012836 A1	09-08-2001